SATELLITE SERVICES SYSTEM ANALYSIS STUDY

volume 5 — programmatics

(NASA-CR-167613) SATELLITE SERVICES SYSTEM ANALYSIS STUDY. VOLUME 5: PROGRAMMATICS Final Report (Grumman Aerospace Corp.) 112 p HC A06/MF A01 CSCL 22A
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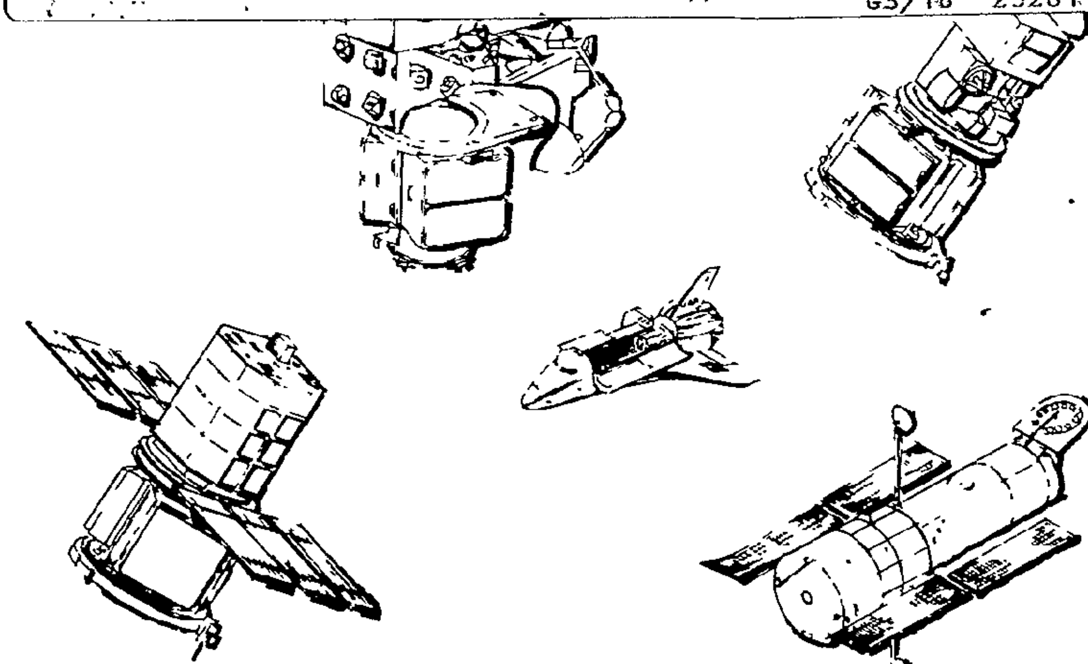

GRUMMAN AEROSPACE CORPORATION

SATELLITE SERVICES SYSTEM ANALYSIS STUDY

volume 5 — programmatics

prepared for

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
Houston, Texas 77058

by

Grumman Aerospace Corporation
Bethpage, N.Y. 11714

NAS9-16120
DRL T-1600
MA-834T
LINE ITEM 4
REPORT CSS-SSS-RP009

August 1981

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FOREWORD

The Satellite Services System Analysis Study (SSSAS) was conducted for the Lyndon B. Johnson Space Center and directed by Contracting Officer's Representatives (COR), Mssrs. Reuben Taylor and Gordon Rysavy. Grumman Aerospace Corporation's study manager was Mr. John Mockovciak Jr.

This final report is presented in seven volumes:

Volume 1 - Executive Summary

Volume 2 - Satellite and Services User Model

Volume 2A - Satellite and Services User Model - Appendix

Volume 3 - Service Equipment Requirements

Volume 3A - Service Equipment Requirements - Appendix

Volume 4 - Service Equipment Concepts

Volume 5 - Programmatics

This volume contains the service equipment utilization analysis, development/production schedules, program cost estimates, and facility/advanced technology requirements. Appendix A to this volume presents a preliminary Program WBS Dictionary; Appendix B identifies equipment utilization by service function, satellite class, and by year; and Appendix C summarizes the utilization of each piece of service equipment. User charges are also presented for each item of service equipment and for representative service missions.

ACRONYMS

Abbreviations and acronyms used frequently throughout the Satellite Services System Analysis Study (SSSAS) are defined as follows:

ACS - Attitude Control System

AFD - Aft Flight Deck

ASM - All Sky Monitor

AXAF - Advanced X-Ray Astrophysics Facility

CCTV - Closed Circuit Television

C & DH - Command & Data Handling

C & DL - Command & Data Link

C/O - Checkout

DDT&E - Design, Development, Test & Evaluation

DoD - Department of Defense

DOF - Degrees of Freedom

EMU - Extra-Vehicular Mobility Unit

EVA - Extra Vehicular Activity

FSS - Flight Support System

GAC - Grumman Aerospace Corporation

GEO - Geosynchronous Earth Orbit

GRAVSAT - Earth Gravity Field Survey Mission

GRO - Gamma Ray Observatory

GSE - Ground Support Equipment

HEAO - High Energy Astronomy Observatory

HPA - Handling & Positioning Aid

IR - Infrared

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IRAD - Independent Research and Development

IUS - Inertial Upper Stage

IVA - Internal Vehicular Activity

JSC - Johnson Space Center

KSC - Kennedy Space Center

LAPC - Large Area Proportional Counter

LASS - Large Amplitude Space Simulator

LASSII - Low Altitude Satellite Studies of Ionospheric Irregularities

LEO - Low Earth Orbit

LOS - Line-Of-Sight

MDF - Manipulator Development Facility

MFR - Manipulator Foot Restraint

MMS - Multimission Modular Spacecraft

MMU - Manned Maneuvering Unit

MRV - Manned Reconnaissance Vehicle

MTV - Maneuverable Television

NOSS - National Oceanic Satellite System

OAO - Orbiting Astronomical Observatory

OBC - Onboard Checkout

OCC - Operations Control Center

OCP - Open Cherry Picker

OMS - Orbital Maneuvering System

PAM A - Payload Assist Module (type) A

PAM D - Payload Assist Module (type) D

PIDA - Payload Installation & Deployment Aid

PM I/II - MMS Propulsion Module I & II

POCC - Payload Operations Control Center

POM - Proximity Operations Module

RCS - Reaction Control System

RMS - Remote Manipulating System

ROM - Rough Order of Magnitude

S/C - Spacecraft

SE&I - System Engineering & Integration

SMM - Solar Maximum Mission

SRM - Solid Rocket Motor

SSS - Satellite Services System

SSSAS - Satellite Services System Analysis Study

S/S - Subsystem

S/SUM - Satellite and Services User Model

STE - Special Test Equipment

STS - Space Transportation System

TDRS(S) - Tracking & Data Relay Satellite (System)

TMS - Teleoperator Maneuvering System

TV - Television

UARS - Upper Atmosphèric Research Satellite

UV - Ultraviolet

VSS - Versatile Service Stage

WBS - Work Breakdown Structure

WETF - Weightless Environment Training Facility

WIF - Water Immersion Facility

WRU - Work Restraint Unit

XTE - X-Ray Timing Explorer

INTRODUCTION

Programmatic tasks within the Satellite Services System Analysis Study (SSSAS) consisted of tasks 5, 7, and 8. Their objective was to scope the overall program and resources needed for development and operation of a Satellite Services System. Assessment of program requirements covered system operations through 1993 and was completed in preliminary form (or, rough-order-of magnitude: ROM) in Part 1, Task 5 of the study. Program requirements were based on the system and equipment concept definitions derived in Part 1, Tasks 3 and 4.

In Part 2 of the study, program requirements were refined based on equipment preliminary design and analysis completed in Task 6. This refinement pertained to Tasks 7 and 8, in which equipment development planning and program planning were updated. Schedules, costs, equipment utilization, and facility/advanced technology requirements were included in the update. In addition, equipment user charges were developed for each piece of equipment and for representative satellite servicing missions.

The products of this programmatics activity, including the approach to and development of program requirements, are presented in this volume.

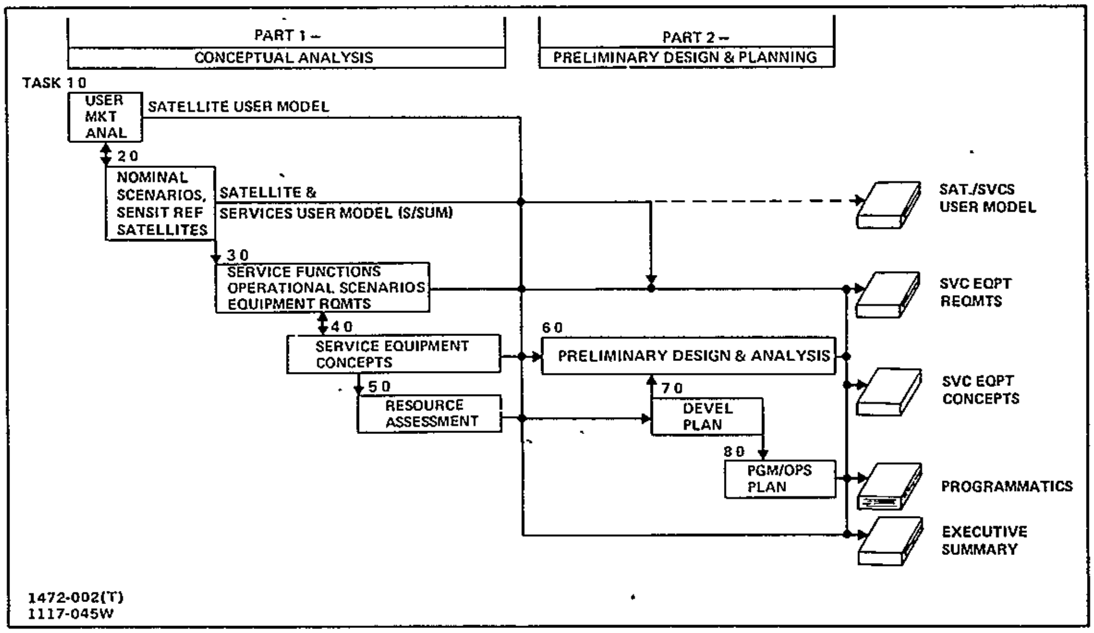

Fig. A Study Logic & Major Outputs

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Methodology

1 - METHODOLOGY

The first step in the development of SSS program requirements was to establish a program Work Breakdown Structure (WBS). This WBS and a corresponding dictionary (see Appendix A) define the scope of the program and provide the framework to develop a program cost estimate. The top level WBS established for this program is shown in Fig. 1-1.

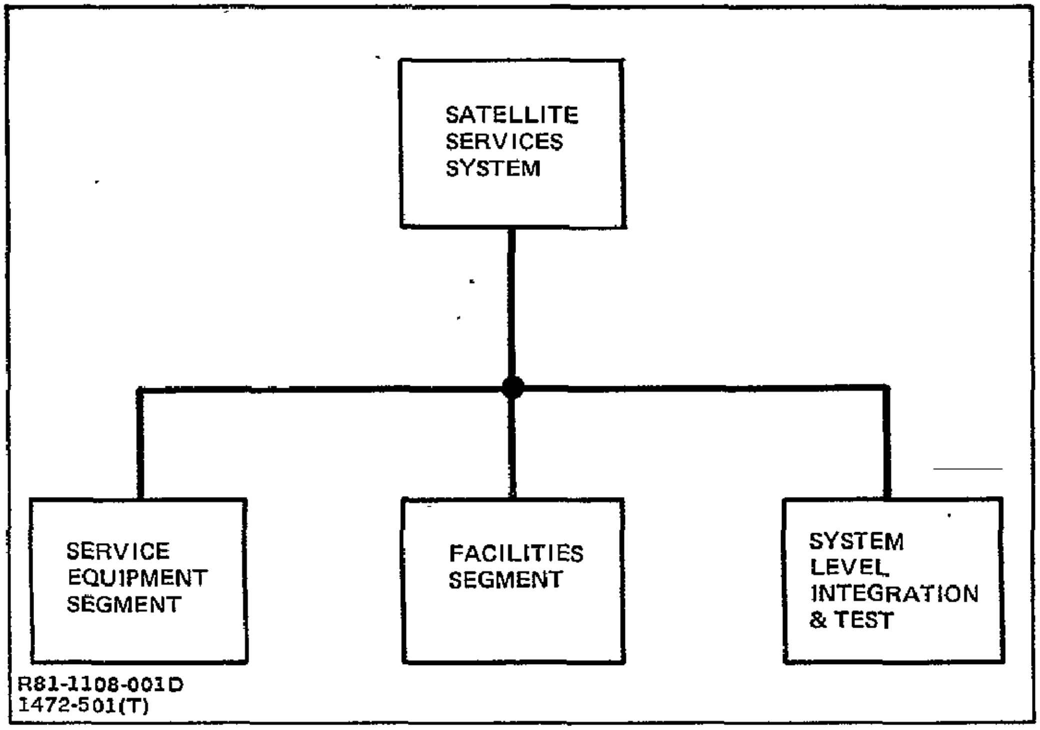

Fig 1-1 Preliminary WBS — Satellite Services System

The format of this WBS and its lower level breakdown can be characterized as follows:

- Conforms with the standard WBS established by the Standardization Subgroup of the Joint Government/Industry Space Systems Cost Analysis Group
- Is compatible with Grumman's computerized cost model
- Formulates estimates for equipment and support functions to enable calculation of a user fee charge
- Categorizes work effort consistent with probable NASA contracting methods.

The programmatic approach utilized to develop preliminary SSS program requirements is presented in Fig. 1-2, and is consistent with the WBS described herein.

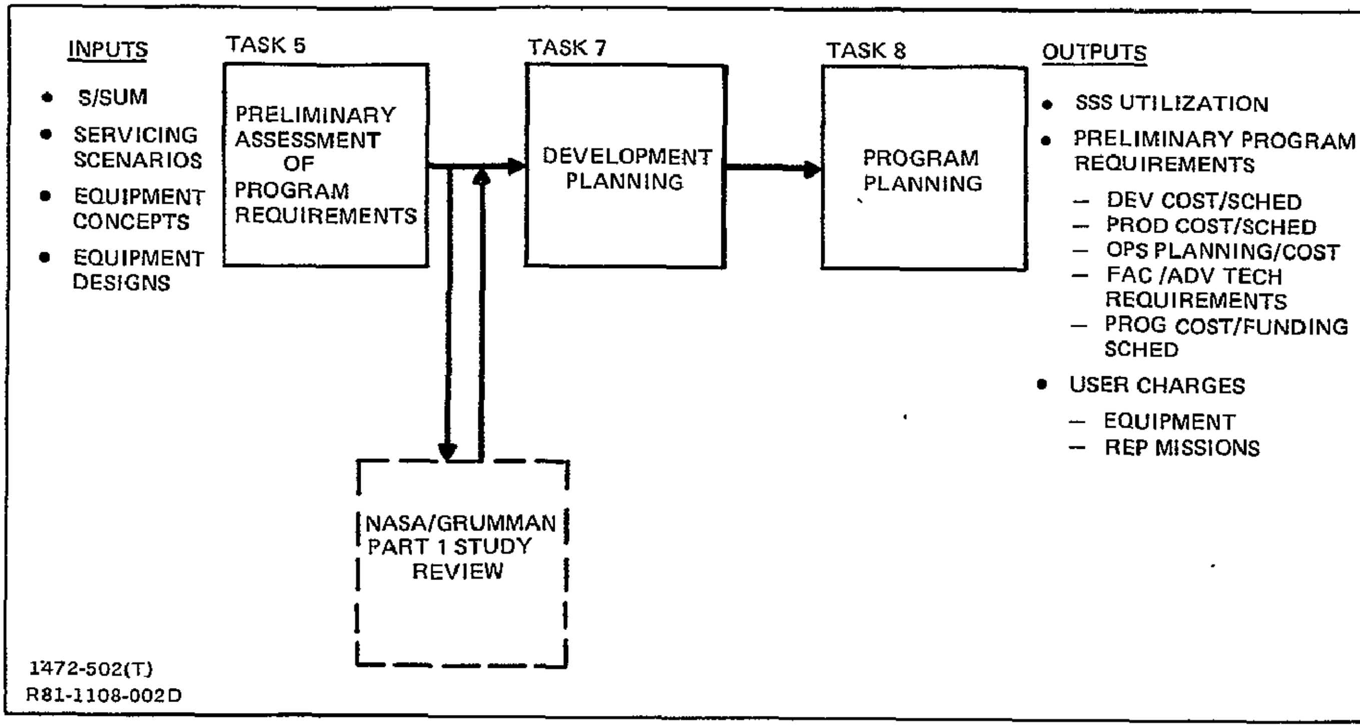

Fig 1-2 Programmatics Approach

To develop these requirements, the S/SUM mission model was used in which satellite users are organized into the following classes:

- Sortie missions
- Planetary satellites
- GEO satellites
- Direct delivery/servicing satellites
- LEO/Propulsion satellites
- DoD missions.

Additional inputs included servicing scenarios derived for Initial Launch, Revisit, and Earth Return service events, as well as equipment concepts/designs defined by this study.

Using these inputs, SSS equipment utilization was established for each mission event or service function by satellite class covering each year from 1983 through 1993.

Data was then summarized by specific equipment item to obtain an annual usage figure for all functions and satellite classes. The end result was a complete utilization schedule for all equipment during the 1983 through 1993 operational period.

Considering equipment complexity from an operational turnaround viewpoint and the size of the planned Orbiter fleet, a required quantity and production schedule for each piece of service equipment was established. These production requirements, together with DDT&E requirements and Grumman-formulated facilities/operations concepts, provided the basis from which preliminary SSS program costs were developed.

The actual equipment utilization analysis and program planning/costing were performed in iterative fashion. In the initial process, the results were developed and presented at the Part 1 study review. NASA feedback to the Grumman presentation and the results of the Task 6 preliminary design were then reflected in the programmatics activity during Part 2 of the study. The end results of this iterative programmatics activity are presented in this report. The format is consistent with the WBS: one section per WBS segment followed by sections which cover program cost and user charges.

Service Equipment

2 - SERVICE EQUIPMENT

2.1 UTILIZATION

SSS requirements were established by relating service equipment usage to the service events in the Satellite and Services User Model (S/SUM). To determine service equipment production quantity and schedule requirements, an equipment utilization analysis was performed which included the following ground rules and assumptions:

- RMS/FSS Tilt Table is prime usage through 1985
- RMS/HPA is prime usage from 1986 and beyond
- All scenarios include equipment for backup of mechanical device failures
- 20% of payload missions each year will require optional services
- Propulsion for LEO/Propulsion class satellites through 1986 is provided by an integral propulsion stage
- Propulsion for LEO/Propulsion class satellites after 1986 is provided by the VSS
- MMU/WRU with POM (end effector) is treated as one system
- IUS/PAM A/PAM D include retention structure, spin table, and tilt table consistent with their system definitions
- Debris removal missions are excluded.

These ground rules and assumptions were then applied to each service event and satellite class identified within the S/SUM from 1983 through 1993. Figure 2-1 shows the format used to develop this utilization data. Equipment to be utilized for a given satellite revisit mission is indicated by an "X" in the appropriate column. Detailed data sheets were prepared in this format for each service event and satellite class by year; they are documented in Appendix B of this volume.

LEO/PROP. SAT MISSIONS '89

NOMINAL EQUIPMENT

SATELLITE	EQPT STOWAGE PROVISIONS	FLUID TRANSFER SYSTEM	TILT TABLE	RMS	WK PLTFM TILT TABLE	OCP/RMS	POM	WITH END EFFECTOR	WITH STABILIZER	WITH PAYLOAD HANDLING	HPA	NON-CONT ACS	MTV POM
ERBS – EARTH RAD BUDGET SAT. (E-4)	X	X		X		X		X	X	X	X	X	X
NOAA (E-5)	X	X		X		X		X	X	X	X		
ORBITER CAMERA FREE FLYER (MML)	X^2	X^2		X^2		X^2		X^2	X^2	X^2	X^2		
UARS-UPPER ATMOS RES (E-7)	X^2	X^2		X^2		X^2		X^2	X^2	X^2	X^2		X
OP LAND OBSER SYS (LEP) (R-5)	X	X		X		X		X	X	X	X		
ALL WEATHER MICRO-WAVE (LEP)	X	X		X		X		X	X	X	X		
EARTH SURVEY (LEP)	X	X		X		X		X	X	X	X	X	
LAMAR-LG AREA MOD ARRAY (A-14, GSE)	X	X		X		X		X	X	X	X	X	
OPTIONAL SERVICE MISSIONS													

NOTE: EXPONENT INDICATES NUMBER OF USES

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Fig 2-1 Revisit–Equipment Utilization Summary–HPA Prime Usage

Based on the detailed equipment usage data in Appendix B, a utilization matrix was developed for each item of service equipment. The format for these tabulations is shown in Fig. 2-2 which summarizes the utilization of the HPA for all S/SUM service events by mission category, satellite class, and year. Equipment complexity (relative to operational turnaround and Orbiter fleet size) was also considered when translating equipment utilization into required production quantity and delivery data. HPA utilization frequency, required quantity, delivery schedule, and cumulative uses through 1990 are shown in Fig. 2-2 and similar data for the OCP is presented in Fig. 2-3. Comparable information for each item of SSS equipment is presented in Appendix C of this volume.

MISSION CATEGORY	FREQUENCY OF USE/YEAR										
	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92	'93
A. INITIAL LAUNCH											
(1) DIRECT DEL /SERV	–	–	–	6	10	7	7	6	9	5	7
(2) LEO/PROP SAT.	–	–	–	12	9	10	11	8	5	7	4
(3) DoD	–	–	–	11	12	11	7	7	7	8	4
(4) PLANETARY	–	–	–	6	1	1	2	–	1	1	4
(5) GEO SAT.	–	–	–	15	17	22	24	26	21	21	31
(6) SORTIE	–	–	–	–	–	–	–	–	–	–	–
B. REVISIT											
(1) DIRECT DEL /SERV	–	–	–	2	4	7	9	9	9	11	12
(2) LEO/PROP SAT.	–	–	–	1	7	8	10	12	11	7	12
C. EARTH RETURN											
(1) DIRECT DEL/SERV	–	–	–	1	3	2	2	4	4	2	3
(2) LEO/PROP SAT.	–	–	–	1	3	3	3	6	7	7	4
TOTAL USES	–	–	–	55	66	71	75	78	74	69	81
NO. UNITS REQD	–	–	–	3	4	5					
REQD DELIVERY	–	–	2	1	1	1		Σ THRU '90 = 345			

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Fig. 2-2 Satellite Service System – HPA Utilization

MISSION CATEGORY	FREQUENCY OF USE/YEAR										
	'83	'84	'85	'86	'87	'88	'89	'90	'91	92	'93
A INITIAL LAUNCH											
(1) DIRECT DEL /SERV											
(2) LEO/PROP SAT.											
(3) DoD											
(4) PLANETARY	←					NONE					→
(5) GEO SAT.											
(6) SORTIE											
B. REVISIT											
(1) DIRECT DEL /SERV	–	–	1	2	4	7	9	9	9	11	12
(2) LEO/PROP SAT.	–	–	–	1	7	8	10	12	11	7	12
C. EARTH RETURN											
(1) DIRECT DEL /SERV	–	–	–	–	–	–	–	–	–	–	–
(2) LEO/PROP SAT.	–	1	–	3	1	1	1	1	–	–	–
TOTAL USES	–	1	1	6	12	16	20	22	20	18	24
NO. UNITS REQD	–	1	2	3	4						
REQD DELIVERY	–	1	1	1	1			Σ THRU '90 = 78			

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Fig. 2-3 Satellite Services System – OCP Utilization

A summary of these service equipment utilizations is shown in Fig. 2-4. The maximum frequency of use per year, cumulative uses through 1990, and required production quantity are identified for each item of equipment. This summary provides a basis for production costing, indicates the relative need for various equipment items, and indicates the potential for standardized equipment usage for orbital service operations.

SSS EQUIPMENT	MAX USE FREQ/YR*	CUM USE*	REQD QTY
• MANIPULATOR FOOT RESTRAINT	82	509	6
• OPEN CHERRY PICKER	22	78	4
• WORK PLATFORM (OCP/TILT TABLE)	3	9	1
• HANDLING & POSITIONING AID	78	345	5
• PYLD INSTALL. & DEPLOYMENT AID	7	36	2
• EQPT STOWAGE PROVISION	21	70	4
• FLUID TRANSFER SYSTEM	21	70	4
• ATTITUDE TRANSFER PKG	7	16	2
• NON-CONTAM ACS	6	28	2
• FLIGHT SUPPORT SYSTEM	36	150	5
• AFD CONTROLS & DISPLAY PANEL	75	553	6
• MMU/WRU/STABILIZER & END EFFECTOR	114	675	12
• MMU/WRU POM ADAPTN	5	20	2
• PYLD HANDLING (MMU/WRU)	21	70	4
• MANEUVERABLE TV	32	111	5
• MTV POM ADAPTN	14	45	2
• SUN SHIELD	11	59	3
• ORBITAL STORAGE	15	80	5
• LIGHTING ENHANCEMENT	15	80	60
• VERSATILE SERVICE STAGE	22	62	4
*THROUGH '90			
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Fig. 2-4 Service Equipment Utilization Summary

The data shown in Fig. 2-4 is identical to information presented at the Part 1 study review except for the following changes:

- The POM/manned version has been deleted from the SSS and replaced by the POM/MTV adaptation. This change was made because the manned POM had low utilization and its function can be handled by the unmanned POM/MTV adaptation
- The MTV is used less frequently to monitor upper stage firings

- The IUS retention structure is provided with the IUS and considered part of the IUS purchase.

These changes reflect NASA feedback to the Part 1 study review and/or Grumman analysis of equipment utilization to consolidate equipment requirements.

2.2 DEVELOPMENT/PRODUCTION

The development/production of SSS equipment falls into either of two categories: integrated or individual equipment development. The integrated category involves development of basic core equipment and supplementary kits that provide a multi-equipment configuration and capability. SSS equipment applicable to this integrated program approach includes:

- MFR
  - Basic
  - OCP (RMS compatible)
  - OCP work platform (Tilt Table compatible)
  - OCP work platform (HPA compatible)
- MMU/WRU
  - POM adaptation*
  - Stabilizer
  - Payload handling
- MTV
  - MTV (Basic)
  - MTV/POM adaptation
- Equipment Stowage/Fluid Transfer
  - Basic structure
  - Fluid transfer package
  - Equipment stowage sections.

* MMU/WRU End Effector version (identified in Part I of the study) was subsequently determined to be identical to MMU/WRU-POM.

Development schedules for this integrated, multiple-use equipment and their appropriate schedule interrelationships are shown in Fig. 2-5. Production and operations phases for this equipment are also presented based on the data developed in the equipment utilization analysis described in Section 2.1. The development/production/operations phasing for the second category of SSS equipment (individual equipment developments) is also presented in Fig. 2-5.

Two points are worthy of note relative to these equipment developments: (1) FSS equipment has been developed and schedule requirements are, therefore, limited to production/ operations; and (2) the HPA is an equipment item that lends itself to a basic unit plus a "kits" design approach. Although not reflected in this study, it is recommended that subsequent efforts (relative to the HPA) adopt this approach.

Figure 2-5 also presents schedules for system-level tests/simulations involving the HPA, MMU/WRU POM, and MTV/POM. Objectives of the tests/simulations are discussed in Section 4.2.

2.3 ADVANCED TECHNOLOGY REQUIREMENTS

According to current design concepts, SSS equipment does not require advanced technology developments; all components and material are current state-of-the-art. Equipment development programs, where required, are conventional as are the system level development tests/simulations noted above.

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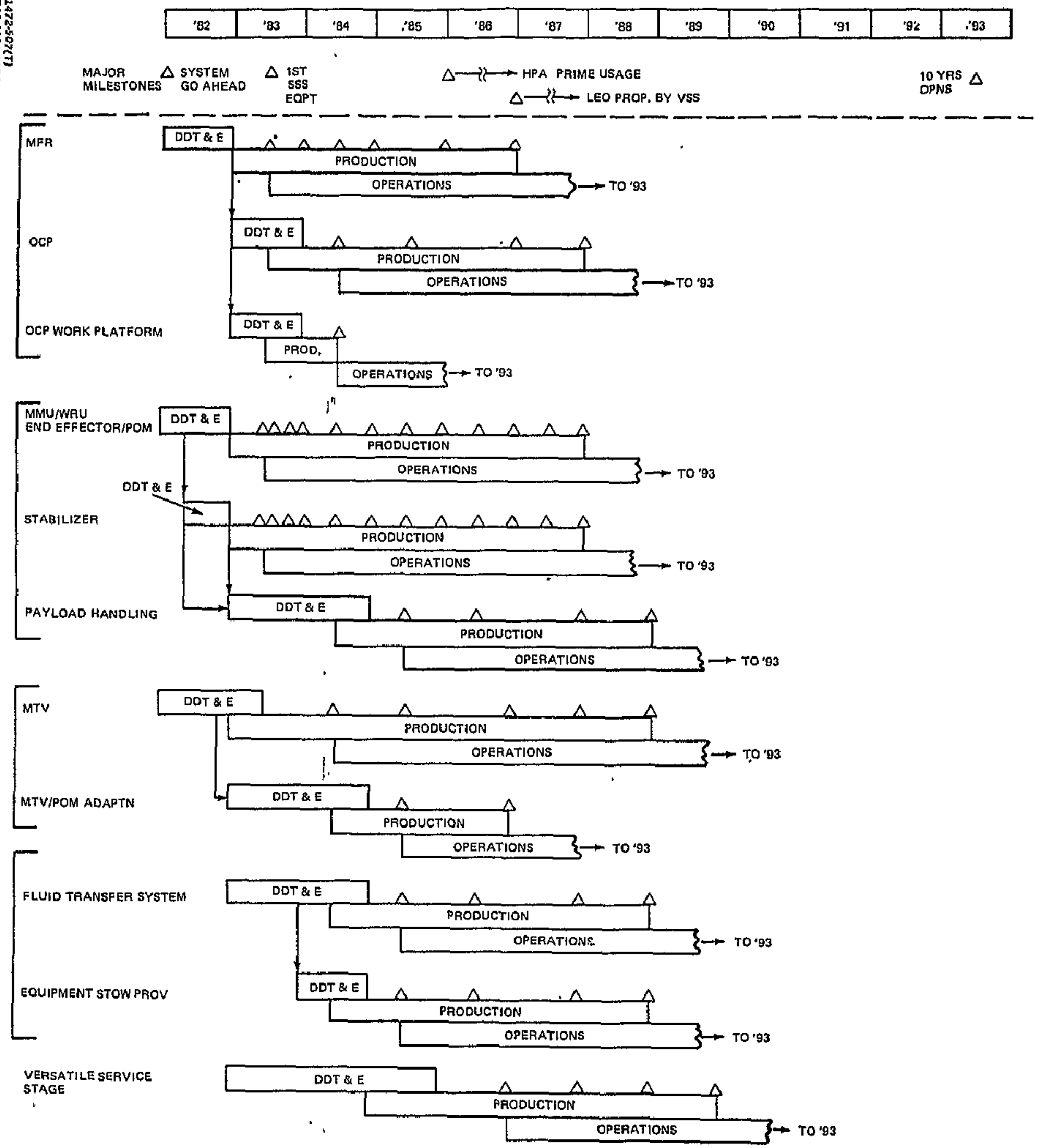

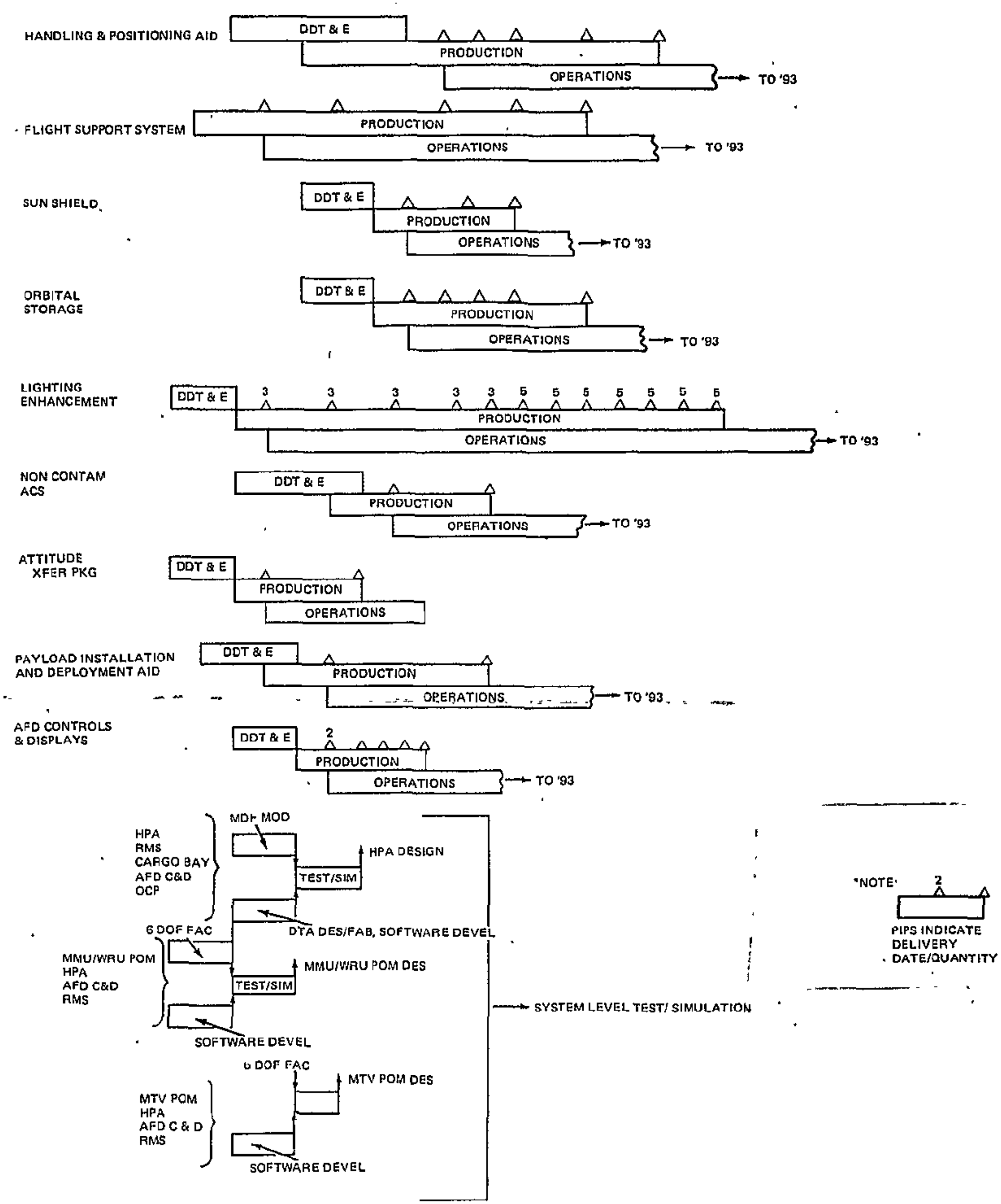

Fig. 2-5 Satellite Services System Development Schedule

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Facility Requirements

3 - FACILITY REQUIREMENTS

Based on the SSS equipment requirements identified to date, contractor and/or government facilities are available for development, manufacture, test and prelaunch/turnaround of the full complement of system equipment. It is recommended, however, that JSC's MDF consider adding a six degree-of-freedom (6-DOF) motion base and computer facilities to enable system-level simulation and crew training with relative 6-DOF motions between SSS equipment and payloads or the Orbiter.

The advantages of a 6-DOF facility can be summarized as follows:

- High fidelity - Relative motions can be reproduced, with limited test hardware but appropriate math model complexity, to a high degree of accuracy
- High flexibility - Different configurations can be mounted on a servo-driven support and math models reprogrammed to produce required motions
- Good availability - Once the servo-driven support structure is available, modification and programming for alternate configurations are reasonable.

Given the advantages of a 6-DOF facility and the wide range of operational complexities involved with the SSS servicing functions, a new NASA/JSC facility that provides this capability is considered a program requirement.

In addition to the new facility, the program will require facility modifications for development and operational support. While basic facilities for system development exist, modification of the Grumman LASS simulation facility, as well as the NASA/JSC MDF and WETF facilities, will be required to support system analysis and derive design/performance specification data. Furthermore, a launch site facility will be needed for SSS equipment initial checkout, turn-around, and update.

System Level Integration and Test

4 - SYSTEM LEVEL INTEGRATION AND TEST

4.1 SYSTEM ENGINEERING AND INTEGRATION (SE&I)

The SE&I function for this program is conventional except that SSS involves a number of equipment items that are functionally independent. Although the development and production of this equipment may be funded by NASA under separate contracts, a system level contractor may be needed to integrate various elements of SSS. The systems level contractor could help JSC to perform a variety of tasks:

- Analysis of service requirements
- Preparation of appropriate specifications
- Documentation
- Definition and control of system interfaces
- Performance of on-orbit operations analyses as well as system integration, analysis, and modeling
- Analysis of equipment designs from the viewpoint of mass properties, loads and dynamics, thermal performance, and contamination
- Review/approval of plans for, and results of, equipment verification
- Performance of safety, reliability, maintainability, configuration management, and quality engineering functions related to satellite services.

The SE&I contractor would also prepare and support development of simulation/ training and ground/flight operations plans and procedures as well as maintain SSS equipment during the operational phase of the program.

4.2 SYSTEM TEST AND EVALUATION

In developing the SSS and equipment concepts, it became apparent that the development of certain equipment would require system level test or simulation. This was due to a significant interaction between a number of service equipment items during functional operation. The flight hardware requirements, or issues identified to date, can be resolved by three system level tests/simulations.

The first system test/simulation involves the HPA and its functional interface with the RMS, AFD Controls and Displays, EVA Operations, STS Cargo Bay, and OCP Work Platform. It is required to verify the capability of the HPA to be stowed and unstowed in the STS cargo bay, to support spacecraft servicing, and to perform berthing and docking operations. The HPA and service equipment will be evaluated in EVA and IVA operating modes. The adequacy of the AFD controls and displays for these HPA operations will be assessed in terms of visibility, RMS, CCTV, and lighting constraints. Most important, this test/simulation will verify the suitability of the HPA to provide a standard satellite interface for on-orbit service operations.

The second and third system level test/simulations involve free-flying simulations of the MMU/WRU-POM adaptation and the MTV POM adaptation. These simulations require local manned control and remote AFD control, respectively. Both would be conducted with a 6-DOF motion base and computer facility to ensure that the manned or unmanned POM approaches, captures, and returns the satellite to the Orbiter for capture by the RMS. The ability to complete these operations will involve functional interfacing of the POMs with the RMS, AFD Controls and Display Panel, and HPA or equivalent.

4.3 SYSTEM OPERATION

The SSS equipment concept definitions and utilization analysis provided a basis for SSS DDT&E and production cost estimates. To complete the preliminary program requirements assessment, Grumman established an operations approach which includes the following features:

- Preparation of generic-type mission plans, timelines, and procedures for SSS equipment
- Establish and maintain an organization for preparation, turnaround, maintenance, and modification of SSS equipment

- Preparation of delta mission plans, timelines, and procedures for mission-specific SSS equipment requirements/usage
- Develop and conduct simulation/training programs for SSS operational utilization.

This operations approach defined a set of operational requirements that provided the basis for development of a program operations cost estimate.

To develop the cost estimate, it was also necessary to establish a number of ground rules/assumptions:

- The organization performing SSS operations includes engineering/technician/support/supervisory personnel working out of NASA provided facilities
- Mission simulation/crew training is conducted in existing or modified facilities as defined by the facilities' WBS
- Mission operational planning requirements are based on Grumman-derived data.

To estimate SSS mission planning requirements, Grumman used the S/SUM data base. Initial Launch, Revisit, and Earth Return service events were plotted and smoothed (see Fig. 4-1) to give a Payload Service Events per year planning requirement. In its present form, this requirement is somewhat conservative since service events for the 1990s are not well defined but are expected to continue to grow rather than level off as indicated by the curve in Fig. 4-1.

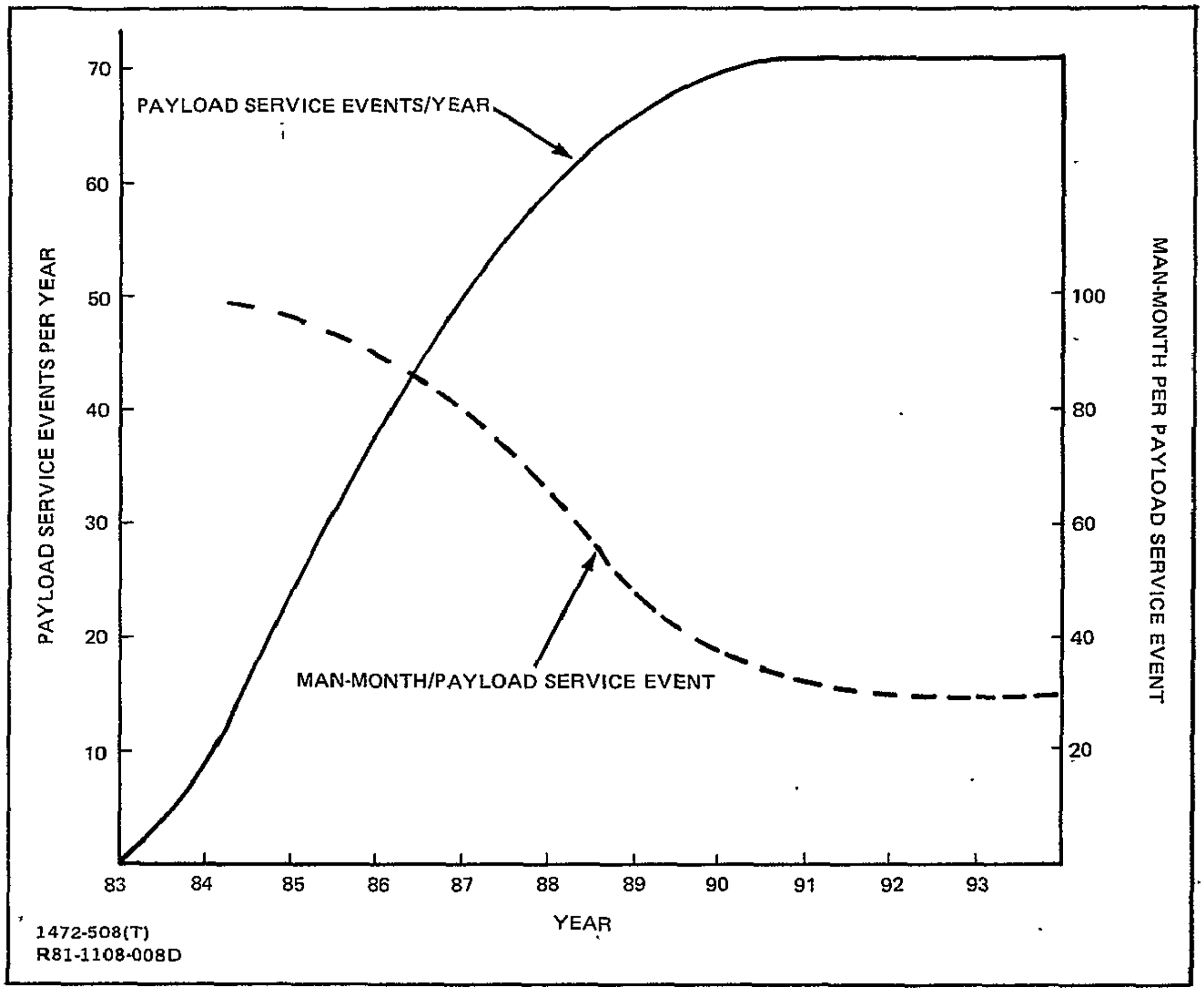

Fig 4-1 Operational Planning Requirements

Figure 4-1 also includes a Man-Month per Payload Service Event curve representing the unique planning effort required for each service event. This unique planning effort supplements the generic mission planning data consistent with our defined operations approach. The initial part of the curve is based on past experience, and the "learning-curve" aspect of the manpower requirement reflects the reduction in requirements due to standardized operations. The "learning-curve" aspect continues into the late 1980s due to continuous introduction of new service equipment. This manpower planning requirement and the service events/year curves provided the estimate for a major portion of the program operations costs.

Program Costs

5 - PROGRAM COSTS

5.1 COST SUMMARY

To determine program costs that are consistent with available equipment concepts and design definitions, the following costing approach was established:

- Develop DDT&E, production and operations (10 year) costs for Satellite Services System
- Exclude mission hardware, STS, and propulsion stage costs
- Include quoted or projected production costs only for developed equipment or that which is under development
- Utilize study-derived DDT&E and production cost estimates for equipment that has been defined by concept studies
- Derive DDT&E and production cost estimates for new equipment concepts
- Base production quantity/schedule on utilization analysis
- Base operations cost on assumed operations concept.

The development of a program cost estimate also required the establishment of the following ground rules/assumptions:

- Cost data in 1980 constant dollars
- Program costed per Grumman proposed WBS
- New equipment estimates based on standard CERs and cost factors
- Equipment level facility and test costs included in equipment estimates
- System level simulation/test
  - Three test article/programs required
  - 6-DOF facility required at JSC

- KSC/JSC and contractor facility mods required for simulation/test and operations activities

- IUS and PAM A/D costs excluded.

These ground rules/assumptions provided an understanding of the scope of particular costs and a basis for interpreting the cost results.

The resultant program cost estimate is detailed in Fig. 5-1. This ROM estimate shows the costs for the service equipment segment (including 20 pieces of SSS equipment), facilities segment, and the system level integration and test segment. Costs are presented by program phase (i.e., DDT&E, Production, and Operations) and in total. DDT&E costs are included as applicable, production costs are for the equipment quantities defined in Fig. 2-4, and reflect learning curve effects. Operations costs cover 10 years of system operation.

COST ELEMENT	DDT & E	PRODUCTION			OPERATIONS	TOTAL
		TFU*	QTY	TOTAL		
SAT SERV SYSTEM	317	96.2		355	151	823
• EQUIPMENT SEGMENT	301	94.3		348	–	649
– MTV						
o BASIC	7	5.8	5	26	–	33
o POM ADAPN	14	13.0	2	24	–	38
– MFR						
o BASIC	3	0.2	6	1	–	4
o OCP/RMS	20	2.0	4	7	–	27
o OCP WORK PLATFORM	13	2.0	1	2	–	15
– MMU/WRU						
o BASIC MMU/WRU CORE	10	8.5**	12	76.4	–	86.4
o END EFFECTOR/POM	9.2	1.2	12	6.1	–	15.3
o STABILIZER	0.74	0.4	12	3.9	–	4.6
o BASIC WRU CORE WITH END EFFECTOR/STABILIZER	19.9	2.0	12	17.1	–	37.0
o PYLD HDLG	0.52	0.1	4	0.48	–	1
– FLD XFER/DRY STORAGE RACK	20	8.4	4/4	30	–	50
– HPA	37	8.3	5	37	–	74
– PIDA	10	11.0	2	23	–	33
– FSS	–	3.5	4	16	–	16
– SUN SHIELD/ORBITAL STORAGE	10	2.5	3/5	9	–	19
– LIGHT ENHANCEMENT	0.4	0.1	60	2	–	2.4
– NON-CONTAM ACS	39	9.4	2	18	–	57
– ATTITUDE XFER PKG	0.4	0.1	2	0.2	–	0.6
– VSS	73	17.0	4	63	–	137
– AFD CONT & DISPLAY	2	0.7	6	4	–	6
– SOFTWARE	17			–	–	17
– SERVICES (LOGISTICS/MGMT)	13			–	–	13
• FACILITIES SEGMENT	4			–	–	4
– GROUND OPS	1					1
– TRAINING & SIMULATION	3					3
• SYS LEVEL I & T SEGMENT	13			6	151	170
– SE & I/SYS TEST	7.1			3	–	10.1
– SERVICES (MGMT/OPS)	5.4			3	151	159.4

* THEORETICAL FIRST UNIT
** INCL 7.0 MIL FOR MMU

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Fig. 5-1 Satellite Services System Cost Summary ROM Cost Estimates – 1980 Dollars (In Millions)

A number of important points on the cost data summarized in Fig. 5-1 are worthy of note. The first four items: MTV, MFR, MMU/WRU, and Wet/Dry Storage Rack (Fluid Transfer/ Equipment Stowage Rack); are considered as four development projects in which a number of service equipment items would be developed around a single core unit using a "kit" design approach as described in Subsection 2.2.

The MMU/WRU development project will require further effort to update the cost estimate presented. First, current costs exclude MMU development costs, but do include MMU production costs. Secondly, a late development in this study has indicated that the MMU/WRU End Effector and MMU/WRU-POM configurations can be identical. Therefore, with further definition and analysis, the MMU/WRU costs presented in Fig. 5-1 can most likely be reduced.

The Wet/Dry Storage development project assumes the development of a common primary support structure that would be used for both the Equipment Stowage and Fluid Transfer System service equipment. Although development and production costs are shown for the combined equipment in Fig. 5-1, production costs have been allocated to Equipment Stowage and Fluid Transfer equipment for the common structure, as well as for hardware that is applicable to each. The Wet/Dry Storage ROM estimate is considered "very loose" at this time for two reasons:

- A wide variety of potential (dry) package geometries/mass may be required, which could dictate unique (no standard) support arrangements
- Fluids replenishment could involve direct tankage/fluid replacement and/or transfer of propellants via a special fluids transfer system.

The diversity of potential requirements for "dry" and "wet" storage is apparent. More refined definitions of satellite and propulsion (stage) requirements are needed than are presently available. This service equipment area is, therefore, recommended for further study.

Relative to other individual equipment developments, the FSS has already been developed and only production costs are included in the cost summary. As noted earlier, the HPA is amenable to a "kit" design approach and is, therefore, subject to cost refinement as the current Grumman OBCES* study evolves. The ROM estimate for AFD controls and displays is strictly for the control/display function and assumes that any microprocessing requirement will be handled via Orbiter computers, or a user-provided microprocessor.

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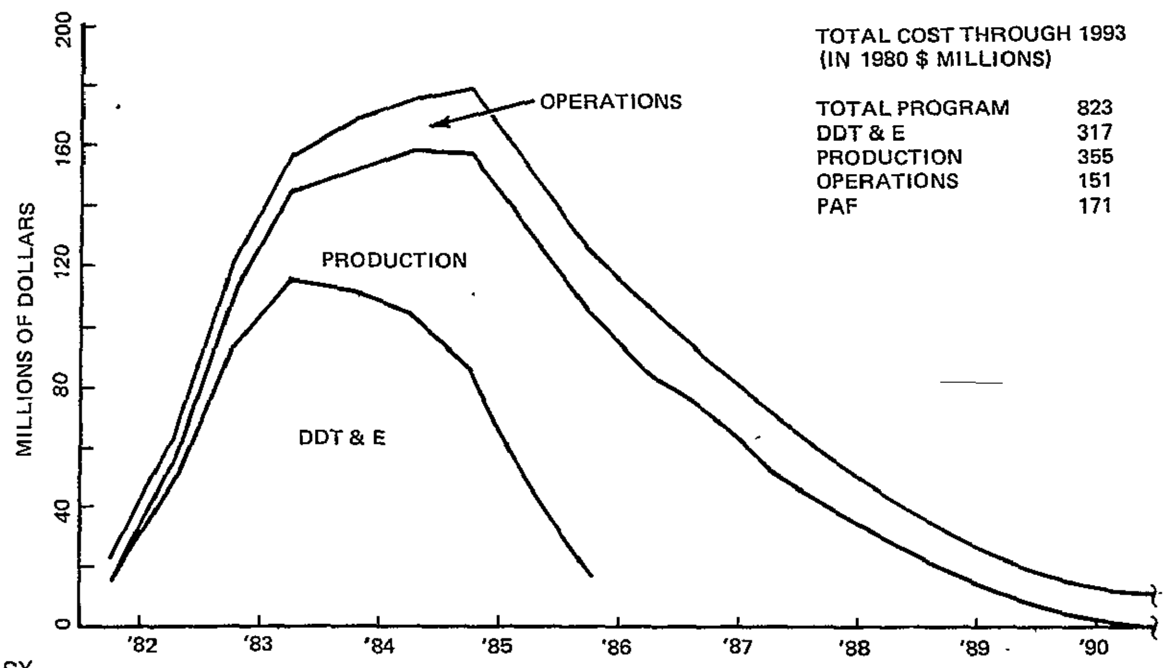
*Orbiter Based Construction Equipment Study

5.2 FUNDING SCHEDULES

The program cost estimate was converted to a program funding schedule by the application of spreading curves to major WBS elements with appropriate start and completion dates. The result (see Fig. 5-2) includes funding schedules and annual cost increments for each program phase and in total. This funding schedule reflects the service events projected in the S/SUM model, assumptions of various equipment usage for each of the service events, and service equipment production quantities over the 10 year time frame. Note that the curves and yearly increments are presented only through 1990 (due to computer program limitation of 20 inputs and our desire for semiannual input definition) although the cumulative totals are given through 1993.



DISTRIBUTION THROUGH 1990 (IN 1980 $ MILLIONS)

	'82	'83	'84	'85	'86	'87	'88	'89	'90
DDT & E	32	101	108	67	9	0	0	0	0
PROD	3	23	47	77	85	62	37	17	3
OPS	6	12	16	20	20	16	14	12	6
TOTAL	41	136	171	164	114	78	51	29	9

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Fig. 5-2 Satellite Services System Funding Schedule

Service equipment hardware items, which are considered as key generic elements in the SSS, are needed early in the program to provide viable services to the user community. Hardware items are as follows:

Backup/Contingency Equipment

- Manipulator Foot Restraint (MFR)
- Work Restraint Unit (WRU) Adaptations

Close Proximity Retrieval Equipment

- Maneuverable Television (MTV)
- MTV - Proximity Operations Module
- WRU - Proximity Operations Module

On-Orbit Servicing Equipment

- Open Cherry Picker (OCP)
- Flight Support System - OCP Work Platform
- Handling and Positioning Aid (HPA)

An estimate of DDT&E and TFU (Theoretical First Unit) costs was prepared for these "core service equipment" items and is shown in Fig. 5-3. As illustrated, these initial core equipment elements could be brought on-line in a 4 to 5 year period within a nominal funding limitation of approximately $50 million.

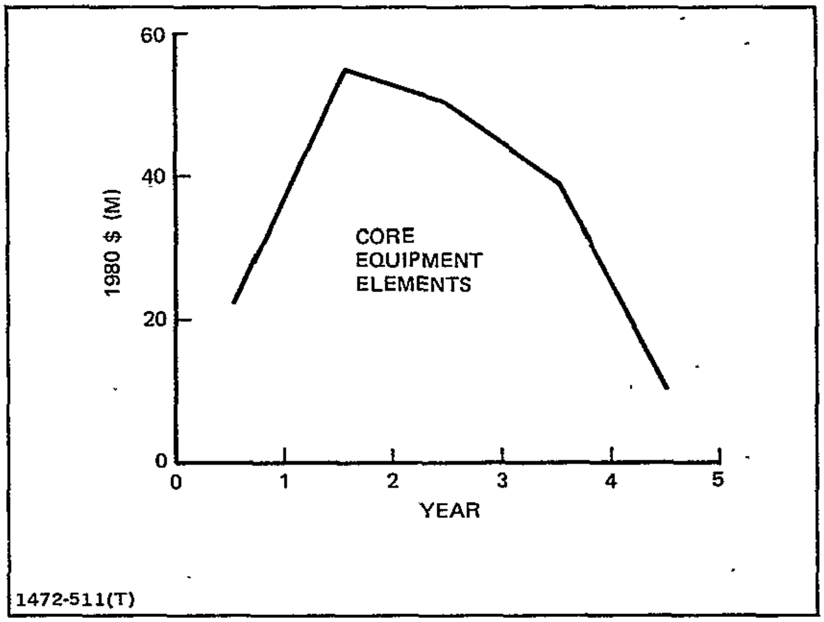

Fig. 5-3 "Core Service Equipment" – DDT&E/TFU Spreads

User Charge

6 - USER CHARGE

6.1 EQUIPMENT USE CHARGE

To determine equipment use charges for the Satellite Services System, the following approach was used:

- Assumptions/Ground Rules
  - User charges over the equipment's lifetime will recover production and operations costs
  - Equipment utilization is based on Grumman's Satellite and Services User Model (S/SUM)
  - Where conceptual definition or hardware exist, production costs for service equipment will be in accordance with prior or actual estimates. Grumman developed estimates will be used if prior estimates are not available
  - Facility costs will be included only for Satellite Services unique facilities, contract direct charge type activities, and the production/operations phase
  - Operations costs will be prorated against equipment utilization
  - Costing will be in 1980 dollars
- Methodology
  - Establish a satellite servicing scenario for the 10 year period (1983 through 1993) using Grumman's S/SUM
  - Summarize the service events by year, the assumed servicing equipment for each service event, and total utilizations per service equipment over the 10 year period
  - Determine the quantity of servicing equipment required to meet the projected utilization

- Establish an operational support organization to implement ground functions for the Satellite Services System; to plan and support flight operations of service equipment; and to provide management, logistics, training/simulation and spares required to operate a Satellite Services System
- Estimate the cost of maintaining an operational support organization
- Establish a user charge factor for production cost equal to the production cost of an item of equipment divided by the number of uses of that equipment over its 10 year life.
- Establish a user charge factor for operations cost which, for an item of equipment, will be proportional to the equipment production cost and uses relative to system production cost and uses. For example:

$$\text{Ops factor} = \frac{1}{2}\left(\frac{\text{eqpt prod cost}}{\text{system prod cost}} + \frac{\text{eqpt uses}}{\text{sys eqpt uses}}\right)\left(\frac{\text{ops cost}}{\text{eqpt uses}}\right)$$

- The user charge factor will equal the sum of the production and operations user charge factors.

In developing the user charges, STS charges were excluded since they depend on the Shuttle mission and its requirements for cargo manifesting, optional flight systems, and optional payload related systems.

Using the methodology described above, user charges were calculated for each of twenty items of satellite service equipment. The results are tabulated in Fig. 6-1. Depending upon equipment quantity, production cost, and frequency of use, the equipment use charge ranges from $17,000 to $640,000. Charges per equipment use are similar to the prices quoted in the STS Reimbursement Guide for optional equipment. Examples of optional equipment quoted prices per flight (in 1980 dollars and without use fee) are:

- Docking module . . . . $ 22,600
- OMS Kit/3 tanks $155,000
- Spacelab complete pallet (element ops) $1,260,000

EQUIPMENT	PRODUCTION QTY	PRODUCTION COST	EQPT USES	OPS COST PER EQPT	OPS CHG PER USE	PROD. CHG PER USE	TOTAL USER CHARGE
• MTV							
– BASIC	5	26	199	8.8	0.044	0.131	0.175
– POM ADAPTN	2	24	64	6.3	0.098	0.381	0.479
• MFR							
– BASIC	6	1	725	11.7	0.016	0.001	0.017
– OCP/RMS	4	7	140	3.9	0.027	0.053	0.080
– OCP WORK PLTFM	1	2	9	0.6	0.070	0.249	0.319
• MMU/WRU							
– MMU	12	66.9	993	15.1	0.015	0.068	0.083
– BASIC WRU CORE WITH END EFFECTOR/ STABILIZER	12	17.1	993	18.9	0.019	0.017	0.036
– BASIC MMU/WRU CORE WITH END EFFECTOR/ STABILIZER	12	84	993	34.0	0.034	0.085	0.119
– PYLD HDLG	4	0.5	132	2.2	0.017	0.004	0.021
– POM	2	2.2	32	1.0	0.031	0.069	0.100
• WET/DRY STORAGE							
– STOWAGE PROV	4	13	132	4.8	0.037	0.096	0.133
– FLUID XFER SYS	4	17	132	5.7	0.043	0.127	0.170
• HPA	5	37	569	17.0	0.030	0.065	0.095
• PIDA	2	23	70	6.0	0.086	0.324	0.410
• FSS	4	16	236	7.2	0.030	0.067	0.097
• SUN SHIELD	3	3	87	2.1	0.024	0.037	0.061
• ORBITAL STORAGE	5	5	120	3.5	0.029	0.046	0.075
• LIGHT ENHCMT	60	2	120	2.3	0.019	0.015	0.034
• NON-CONTAM ACS	2	18	60	4.8	0.080	0.295	0.375
• ATTITUDE XFER PKG	2	0.2	16	0.3	0.019	0.013	0.032
• VSS	4	63	123	15.6	0.127	0.513	0.640
• AFD C&D	6	4	831	13.9	0.017	0.004	0.021

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Fig. 6-1 Equipment Use Charge – Nominal Utilization-Satellite Service System – 1980 Dollars (in millions)

To determine the sensitivity of user charges to equipment utilization, the user charges for each piece of equipment (based on a utilization that was 50% or 200% of the nominal estimated usage) were calculated. The results of these calculations are given in Fig. 6-2 and 6-3. As expected from the costing relationship, the variation in user charges range from a near linear relationship to one that is relatively insensitive to frequency of use, depending on production cost and frequency of use. For example, the user charge per flight for the HPA, based on the nominal utilization rate, is $95,000. The same charges for 50% and 200% of the nominal utilization are $175,000 and $56,000, respectively. On the other hand, the AFD C&D panel has user charges per flight for nominal, 50%, and 200% utilization of $21,000, $27,000, and $18,000, respectively. This sensitivity is shown graphically in Fig. 6-4.

EQUIPMENT	PRODUCTION COST	EQPT USES	OPS COST PER EQPT	OPS CHG PER USE	PROD CHG PER USE	TOTAL USER CHARGE
• MTV						
– BASIC	26	99	7.2	0.073	0.264	0.337
– POM ADAPTN	24	33	5.8	0.181	0.762	0.943
• MFR						
– BASIC	1	362	5.9	0.016	0.003	0.019
– OCP/RMS	7	70	2.7	0.039	0.106	0.145
– OCP WORK PLTFM	2	4	0.6	0.138	0.560	0.698
• MMU/WRU						
– BASIC MMU/WRU CORE WITH END EFFECTOR/ STABILIZER	84	496	26.1	0.053		0.223
– PYLD HDLG	0.5	66	1.2	0.017	0.007	0.024
– POM	2.2	16	0.7	0.046	0.138	0.184
• WET/DRY STORAGE						
– STOWAGE PROV	13	66	3.8	0.058	0.193	0.251
– FLUID XFER SYS	17	66	4.7	0.071	0.255	0.326
• HPA	37	284	12.6	0.044	0.131	0.175
• PIDA	23	35	5.5	0.156	0.648	0.804
• FSS	16	118	5.3	0.045	0.134	0.179
• SUN SHIELD	3	43	1.4	0.032	0.075	0.107
• ORBITAL STORAGE	6	60	2.2	0.036	0.093	0.129
• LIGHT ENHCMT	2	60	1.4	0.023	0.031	0.054
• NON-CONTAM ACS	18	30	4.3	0.144	0.590	0.734
• ATTITUDE XFER PKG	0.2	8	0.2	0.021	0.026	0.047
• VSS	63	61	14.7	0.240	1.035	1.275
• AFD C&D	4	415	7.4	0.018	0.009	0.027

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Fig. 6-2 Equipment Use Charge — 50% Utilization Rate-Satellite Services System — 1980 Dollars (in millions)

EQUIPMENT	PRODUCTION COST	EQPT USES	OPS COST PER EQPT	OPS CHG PER USE	PROD CHG PER USE	TOTAL USER CHARGE
• MTV						
– BASIC	26	398	12	0.030	0.066	0.096
– POM ADAPTN	24	128	7.3	0.057	0.191	0.248
• MFR						
– BASIC	1	1450	23.1	0.016	0.001	0.017
– OCP/RMS	7	280	6.0	0.022	0.027	0.049
– OCP WORK PLTFM	2	18	0.8	0.043	0.124	0.167
• MMU/WRU						
– BASIC MMU/WRU CORE WITH END EFFECTOR/ STABILIZER	84	1986	49.6	0.025	0.042	0.067
– PYLD HDLG	0.5	264	4.3	0.016	0.002	0.018
– POM	2.2	64	1.5	0.023	0.034	0.057
• WET/DRY STORAGE						
– STOWAGE PROV	13	264	6.9	0.026	0.048	0.074
– FLUID XFER SYS	17	264	7.8	0.030	0.064	0.094
• HPA	37	1138	26.0	0.023	0.033	0.056
• PIDA	23	140	7.1	0.051	0.162	0.213
• FSS	16	472	10.9	0.023	0.033	0.056
• SUN SHIELD	3	174	3.4	0.020	0.018	0.038
• ORBITAL STORAGE	6	240	5.0	0.021	0.023	0.044
• LIGHT ENHCMT	2	240	4.2	0.017	0.008	0.025
• NON-CONTAM ACS	18	120	5.7	0.048	0.147	0.195
• ATTITUDE XFER PKG	0.2	32	0.6	0.017	0.007	0.024
• VSS	63	246	17.6	0.071	0.257	0.328
• AFD C&D	4	1662	27.0	0.016	0.002	0.018
1472-514(T)						

Fig. 6-3 Equipment Use Charge — 200% Utilization Rate-Satellite Services System — 1980 Dollars (in millions)

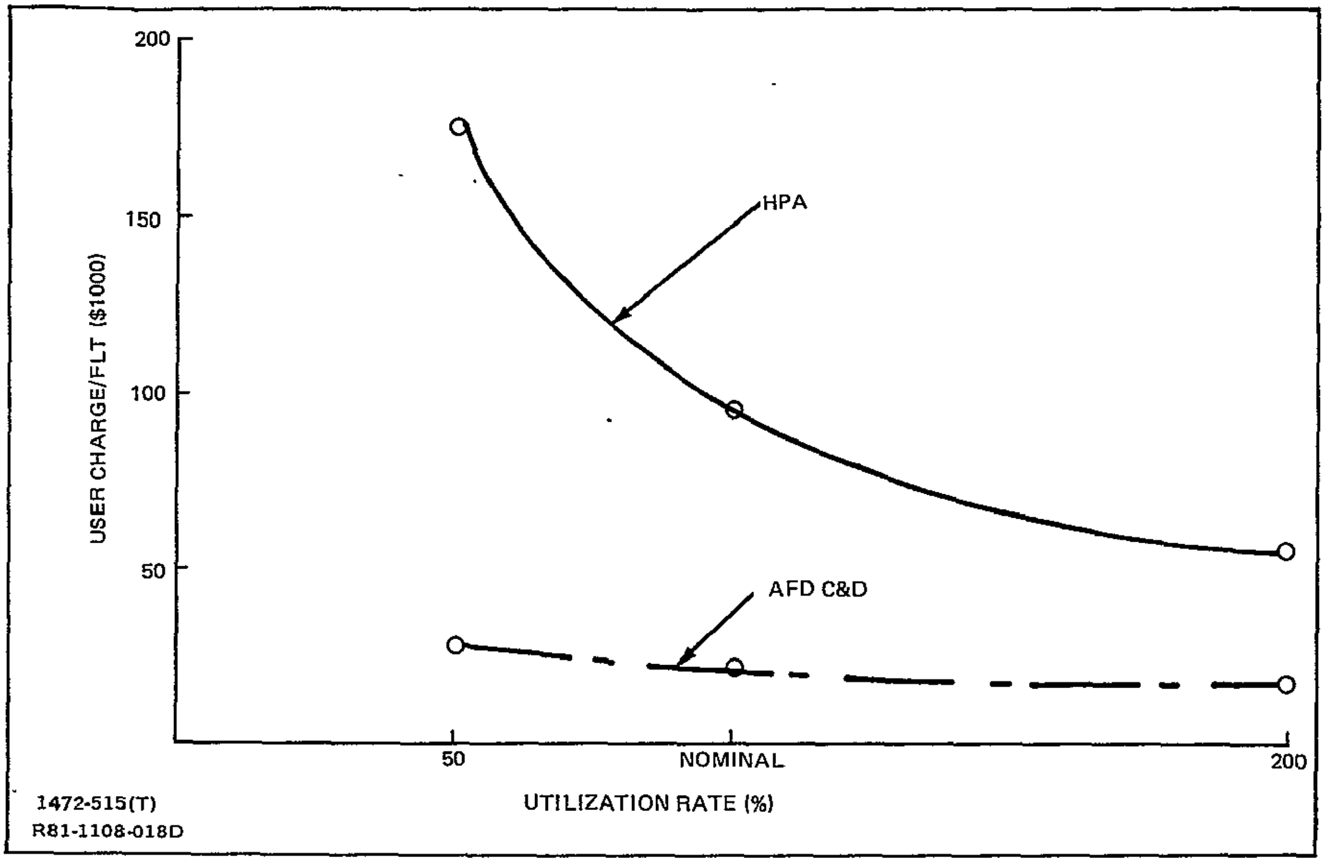


Fig. 6-4 User Charge Sensitivity

6.2 REPRESENTATIVE MISSIONS - SERVICE COSTS

Satellite services user costs are the sum of the equipment use charge, miscellaneous services charges, and the STS transportation charges that apply to the service equipment utilized for a particular STS mission manifest. User costs were assessed for four representative service missions:

- UARS Launch
- UARS Revisit
- SMM Earth Return
- AXAF Revisit.

The service equipment complements assumed for these service missions are shown in Fig. 6-5.

The UARS launch mission reflects a typical complement of service equipment for a satellite deployment mission, including primary and backup service equipment.

The UARS revisit represents a LEO/Propulsion satellite class service mission in which the satellite's LEO operational altitude is above the nominal delivery altitude of

the Orbiter. The Versatile Service Stage (VSS) is used to retrieve, and subsequently return, the satellite to its operational orbit after servicing at the Orbiter.

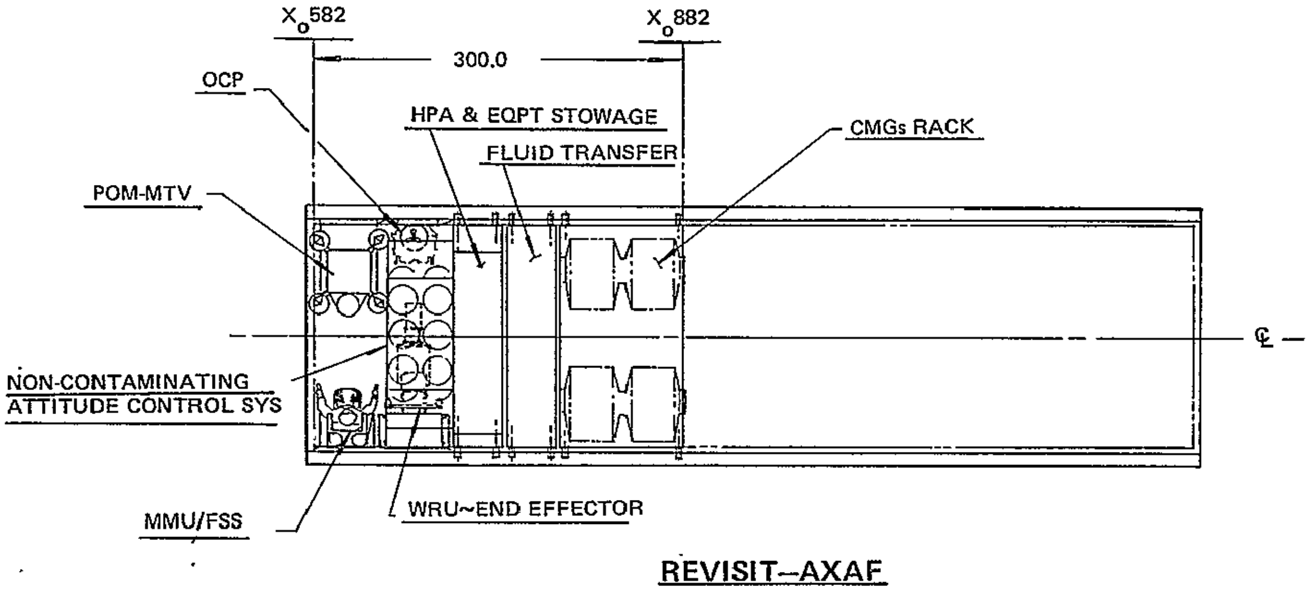
The SMM earth return illustrates a complement of service equipment for an earth return mission. The Orbiter would rendezvous with the satellite to within 1000 ft and accomplish retrieval with a Proximity Operations Module - WRU adaptation.

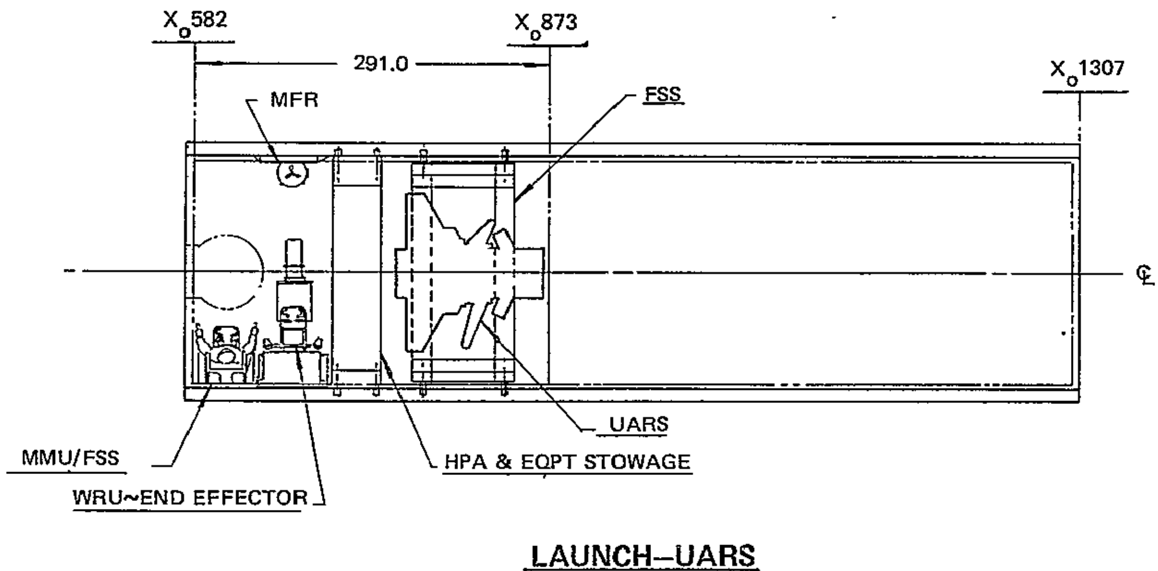
The AXAF revisit represents a service mission involving a contamination sensitive satellite. The Orbiter would rendezvous with the spacecraft to within 1000 ft and accomplish retrieval with a Proximity Operations Module - MTV adaptation.

The basis for development of user costs includes SSS equipment, STS packaging, costing assumptions/ground rules, and mission operations scenarios. The equipment packaging, completed for each of four missions (see Fig. 6-8), provided a basis for determining whether length or weight was the driver for STS transportation charges. In developing the service equipment layouts, all equipment was packaged in the forward section of the cargo bay, including a 4 ft allocation for EVA. In addition, except for the AXAF revisit mission, clearance for an outside airlock was provided.

SERVICE MISSION	SERVICE EQUIPMENT COMPLEMENT
UARS LAUNCH	• FLIGHT SUPPORT SYSTEM • MANIPULATOR FOOT RESTRAINT • MANNED MANEUVERING UNIT • WORK RESTRAINT UNIT – END EFFECTOR ADAPTATION • HANDLING AND POSITIONING AID • REMOTE MANIPULATOR SYSTEM
UARS REVISIT	• VERSATILE SERVICE STAGE • FLUID TRANSFER SYSTEM • HANDLING AND POSITIONING AID • MANEUVERABLE TELEVISION • OPEN CHERRY PICKER • MANNED MANEUVERING UNIT • WORK RESTRAINT UNIT – END EFFECTOR ADAPTATION • REMOTE MANIPULATOR SYSTEM
SMM EARTH RETURN	• FLIGHT SUPPORT SYSTEM • MANEUVERABLE TELEVISION • OPEN CHERRY PICKER • MANNED MANEUVERING UNIT • PROXIMITY OPERATIONS MODULE – WRU ADAPTATION • REMOTE MANIPULATOR SYSTEM
AXAF REVISIT	• HANDLING AND POSITIONING AID • FLUID TRANSFER/EQUIPMENT STOWAGE • NON-CONTAMINATING ACS • PROXIMITY OPERATIONS MODULE – MTV ADAPTATION • OPEN CHERRY PICKER • MANNED MANEUVERING UNIT • WORK RESTRAINT UNIT – END EFFECTOR ADAPTATION • REMOTE MANIPULATOR SYSTEM
1472-516(T)	

Fig. 6-5 Representative Service Missions and Equipment Complements





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Assumptions/ground rules used to develop service cost estimates included:

- All users are civilian U.S. government agencies
- Transportation costs are based on STS Reimbursement Guide
- All shuttle missions are shared payload flights
- MMU/WRU and AFD C&D panels are common service equipment and STS charges are shared, but each user is charged a use fee
- Earth Return and Revisit missions are missions of convenience, i.e., planned as opportunity revisits or retrievals following initial launch (deployment) of payloads
- All costs are in 1980 dollars.

Operations scenarios are based on launch, revisit, and earth return scenarios developed within the study. The scenarios identified the needed service equipment and provided a base for STS packaging and calculation of STS charges as well as equipment use charges. In addition, each mission was analyzed to determine impact on KSC flow and requirements for EVA, days on orbit, and payload specialists.

Based on the equipment packaging, ground rules/assumptions, and operations scenarios defined above, estimated total user costs for representative missions are:

- UARS Launch – \$12.8 million
- UARS Revisit – \$13.2 million
- SMM Earth Return – \$ 9.1 million
- AXAF Revisit – \$16.0 million

Input data and output costs for the representative missions are shown in Fig. 6-7.

Figure 6-8 clearly indicates that the dominant user charge for satellite services is that associated with the STS transportation charges for the service equipment. Miscellaneous service charges are moderate, and equipment usage charges (amortized as a function of total estimated usage) are minimal. Of key significance is the fact that total user charges for revisit missions appear to be about 5-10% (or less) of the cost to build and relaunch a replacement satellite. This clearly indicates that satellite servicing from the Orbiter is cost effective.

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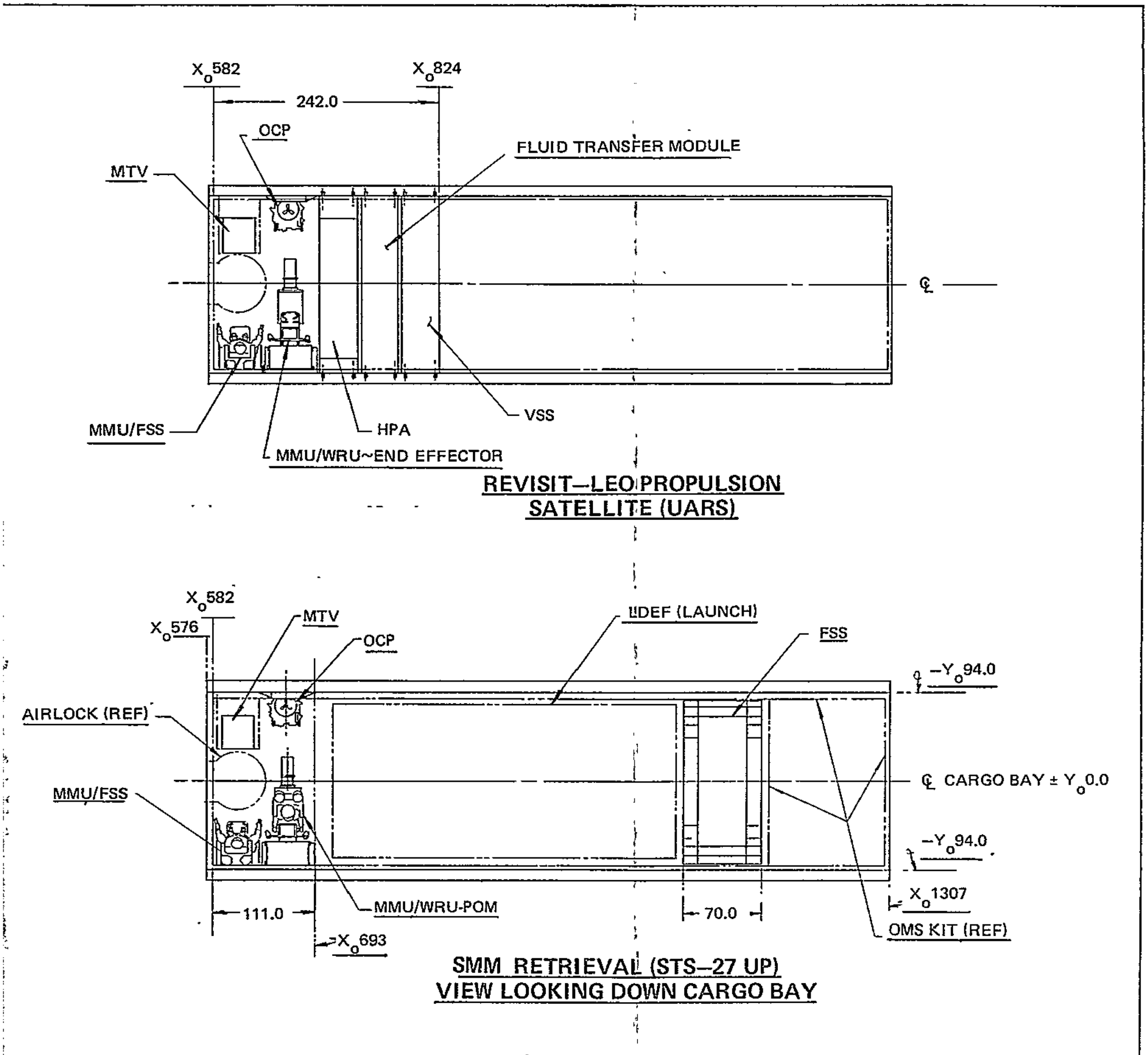

Fig. 6-6 Layout of Satellite Service Equipment in Cargo Bay

UARS LAUNCH MISSION

INPUT	
P/L LENGTH (m)	6.1
P/L WEIGHT (kg)	5317
INCLINATION (deg)	57
GOV = 0, NON-GOV = 1	0
NO. OF EVAs	0
LOITER DAYS (-1)	0
FLIGHT KITS	0.418*
OPTIONAL SVCS	0
KSC FLOW IMPACT	0.27*
OUTPUT	
STS FLIGHTS	12.11*
FLT KITS (SSS USE CHARGE)	0.418*
OPT SVCS	0
EVA	0
LOITER	0
KSC FLOW IMPACT	0.27*
TOTAL USER CHARGE	12.798*
R81-1108-014D	

UARS REVISIT MISSION

INPUT	
P/L LENGTH (m)	4.9
P/L WEIGHT (kg)	5369
INCLINATION (deg)	57
GOV = 0, NON-GOV = 1	0
NO. OF EVAs	2
LOITER DAYS (-1)	3
FLIGHT KITS	1,356*
OPTIONAL SVCS	0.66*
KSC FLOW IMPACT	0.36*
OUTPUT	
STS FLIGHTS	9.728*
FLT KITS (SSS USE CHARGE)	1.356*
OPT SVCS	0.66*
EVA	0.24*
LOITER	0.9*
KSC FLOW IMPACT	0.36*
TOTAL USER CHARGE	13.244
R81-1108-015D	

* MISSION COSTS

SMM EARTH RETURN MISSION

INPUT	
P/L LENGTH (m)	3.7
P/L WEIGHT (kg)	4561
INCLINATION (deg)	28.5
GOV = 0, NON-GOV = 1	0
NO. OF EVAs	1
LOITER DAYS (-1)	1
FLIGHT KITS	0.494*
OPTIONAL SVCS	0.66*
KSC FLOW IMPACT	0.18
OUTPUT	
STS FLIGHTS	7.345*
FLT KITS (SSS USE CHARGE)	0.494*
OPT SVCS	0.66*
EVA	0.12*
LOITER	0.3*
KSC FLOW IMPACT	0.18*
TOTAL USER CHARGE	9.099*
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AXAF REVISIT MISSION

INPUT	
P/L LENGTH (m)	6.4
P/L WEIGHT (kg)	4260
INCLINATION (deg)	28.5
GOV = 0, NON-GOV = 1	0
NO. OF EVAs	2
LOITER DAYS (-1)	2
FLIGHT KITS	1,395*
OPTIONAL SVCS	0.66*
KSC FLOW IMPACT	0,36*
OUTPUT	
STS FLIGHTS	12.706*
FLT KITS (SSS USE CHARGE)	1.395
OPT SVCS	0.66*
EVA	0.24*
LOITER	0.6*
KSC FLOW IMPACT	0.36*
TOTAL USER CHARGE	15.961*
R81-1108-017D	

Fig. 6-7 Representative Mission Costs (1980 Millions of Dollars)

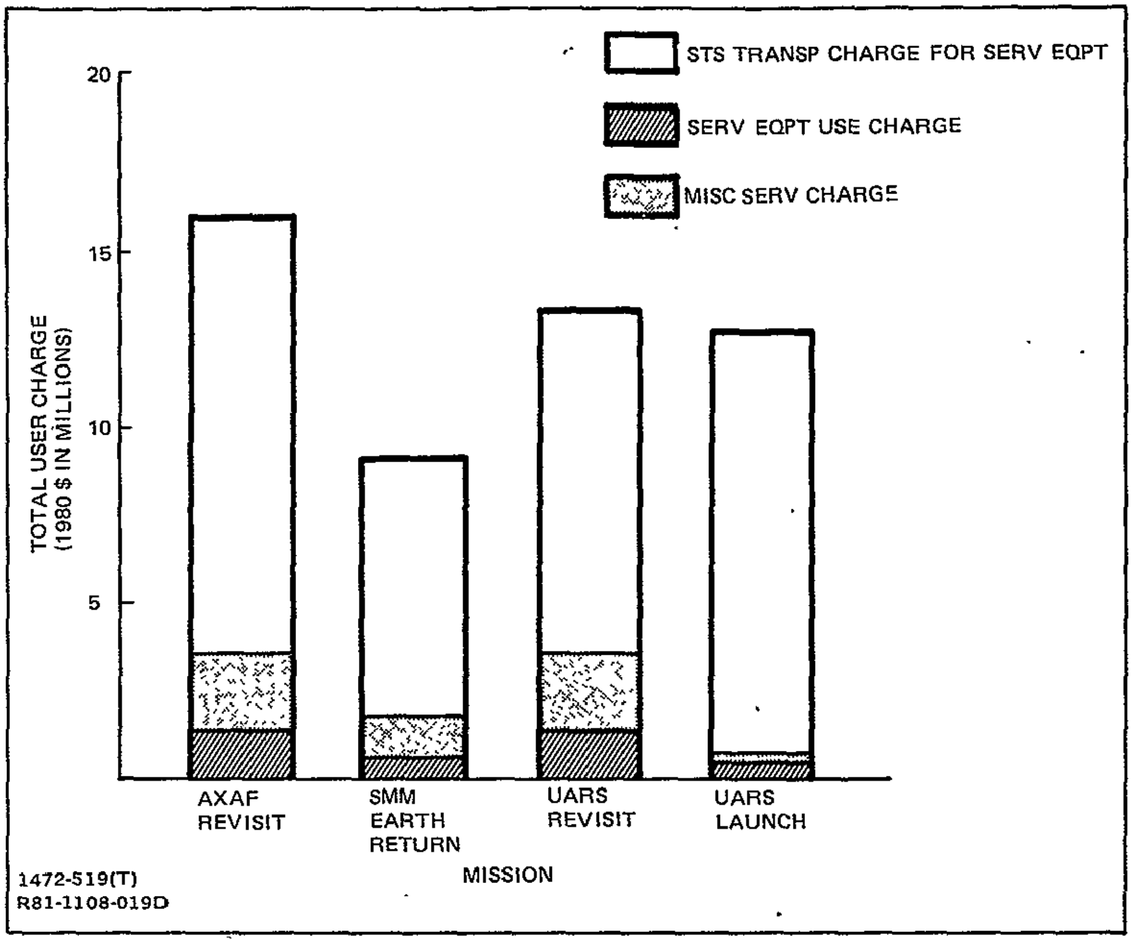

Fig. 6-8 Representative Missions — Service Costs

Since each of the representative missions (in terms of STS charges) were driven by service equipment length, each was analyzed to determine user costs for payload length variations of ±25% in the packaged equipment. In all cases, the packaged equipment length continued to drive the STS charge. Similarly, the effect of varying payload lengths for the SMM Earth Return Mission, with a fixed payload weight, was calculated. The same calculation was also made for varying payload weights with a fixed payload length. These results, plotted in Fig. 6-9, show the breakpoint at which increasing payload length or weight begins to increase user costs. For instance, with a constant service equipment weight of 4561 kg, packaged service equipment lengths above 2.8 m drive the STS charges; below 2.8 m, the STS charges are driven by weight. On the other hand, with a constant packaged service equipment length of 3.7 m, service equipment weights above 6000 kg drive the STS charges; below 6000 kg, STS charges are driven by packaged service equipment length.

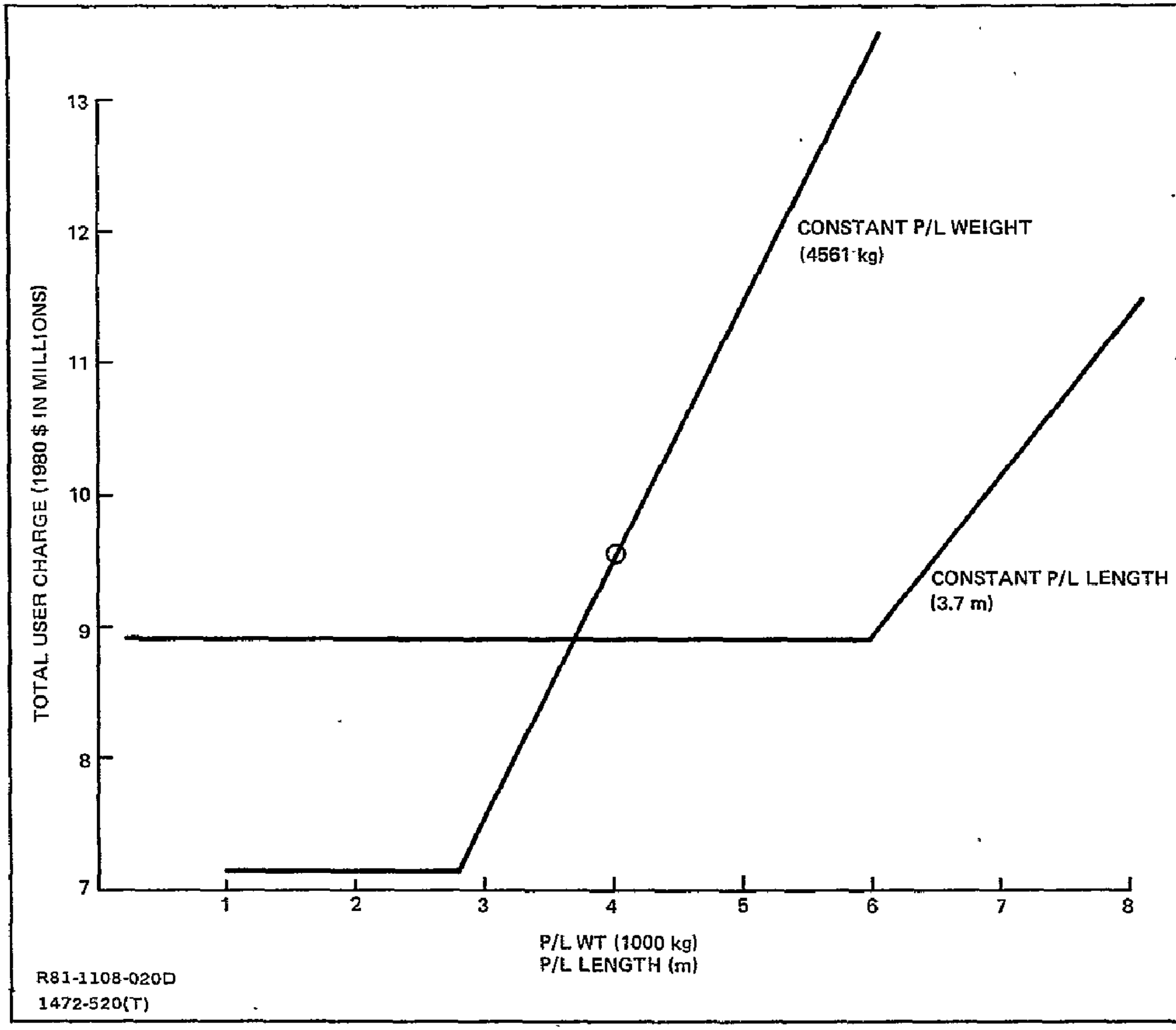

Fig. 6-9 SSM Earth Return Mission Cost vs P/L Length/Weight

Programmatic Observations

7 - PROGRAMMATIC OBSERVATIONS

A summary of the programmatic observations applying to this study follows:

- Service traffic projections and servicing scenarios indicate a high usage frequency for most servicing equipment identified; the opportunity exists to standardize training and on-orbit services operations
- MMU/WRU programmatics require updating since further consolidating of WRU adaptations (and related "kits") appears promising
- HPA should be developed around a basic unit, with "kits" adapted for its many applications
- Fluid Transfer/Dry Storage equipment concepts require further study and amplification
- AFD functional servicing requirements include Controls/Displays for RMS controls, standardized satellite checkout, and close proximity flight control; the latter items require further study and analysis of both C&D requirements and microprocessing needs vs Orbiter capabilities
- Development schedules for a number of equipment items require early go-aheads to meet apparent need dates
- User charges for service equipment appear quite reasonable compared with present optional shuttle flight system charges
- Representative service missions appear to cost approximately 5-10% (or less) of a satellite's replacement cost on-orbit (assumed to include unit cost for production plus relaunch).

Appendix A
Satellite Services System Program
WBS Dictionary

INTRODUCTION

The Satellite Services System program contains all labor and material required for DDT&E, Production, and Operations phases of all program elements. The phases are defined as follows:

<u>DDT&E</u> - Includes all labor, materials, tooling, facilities, studies, and analyses required to determine specification requirements and the subsequent analysis, design, development, evaluation, and redesign of the Satellite Services System and associated equipment.

The following items are included:

- Preparation of
  - specifications
  - drawings
  - parts lists
  - wiring diagrams
  - data reduction
- Development & testing of
  - component hardware
  - subsystem hardware
- Requirements for & analysis of
  - Flight hardware/GSE
    - o Reliability
    - o Maintainability
    - o Quality Assurance
- Coordination between
  - engineering & manufacturing
  - vendors & purchasing.

In addition, costs are included for efforts to complete the planning, design, fabrication, assembly, inspection, installation, and modification of: initial tooling, jigs, fixtures, special test equipment, and trainers/simulators. DDT&E also includes the efforts expended to conduct system design reviews, evaluate the results of those reviews, and perform engineering cost and materials analyses, as well as DDT&E management and engineering that is charged directly to the system, a particular subsystem, or a GSE unit.

Also included under DDT&E are costs associated with system level test articles for both test hardware acquisition and development/qualification testing. Hardware items such as engineering models, breadboards, engineering mockups, and related items required in the development of individual subsystems and components are covered as well. Facility construction/modification and facility/GSE operational readiness activities are also included.

Production - Includes all labor and materials required for the production of space hardware and GSE through the acceptance of this hardware by the Government. Included are all costs associated with:

- Procurement, fabrication, assembly, checkout, and acceptance testing of space hardware and GSE
- Initial spares
- Maintenance of tooling and factory test equipment
- Management and sustaining engineering for liaison support of space hardware and GSE production.

Operations - Includes all costs associated with ground and flight operations and their support. Included are all costs associated with:

- Ground Operations - Receipt, assembly, checkout, servicing, launch support, post-launch support, and maintenance/refurbishment of reusable space hardware; maintenance of GSE and trainers/simulators; and inventory control of operational spares
- Mission Operations - Mission planning, support of ground mission control, and development/implementation of training/simulation programs for flight personnel
- Management and engineering support of system operations.

1 - WBS DEFINITION

The Work Breakdown Structure (WBS) applies to the DDT&E, Production, and Operations phases of the program. When totalled, the cost of WBS elements for all three phases will comprise the total cost of the Satellite Services System program.

Figure A-1 shows the top level breakout of the Satellite Services System composed of:

- 1.1 Service Equipment Segment
- 1.2 Facilities Segment
- 1.3 System Level Integration & Test

Figure A-2 expands the breakouts to the third and fourth levels.

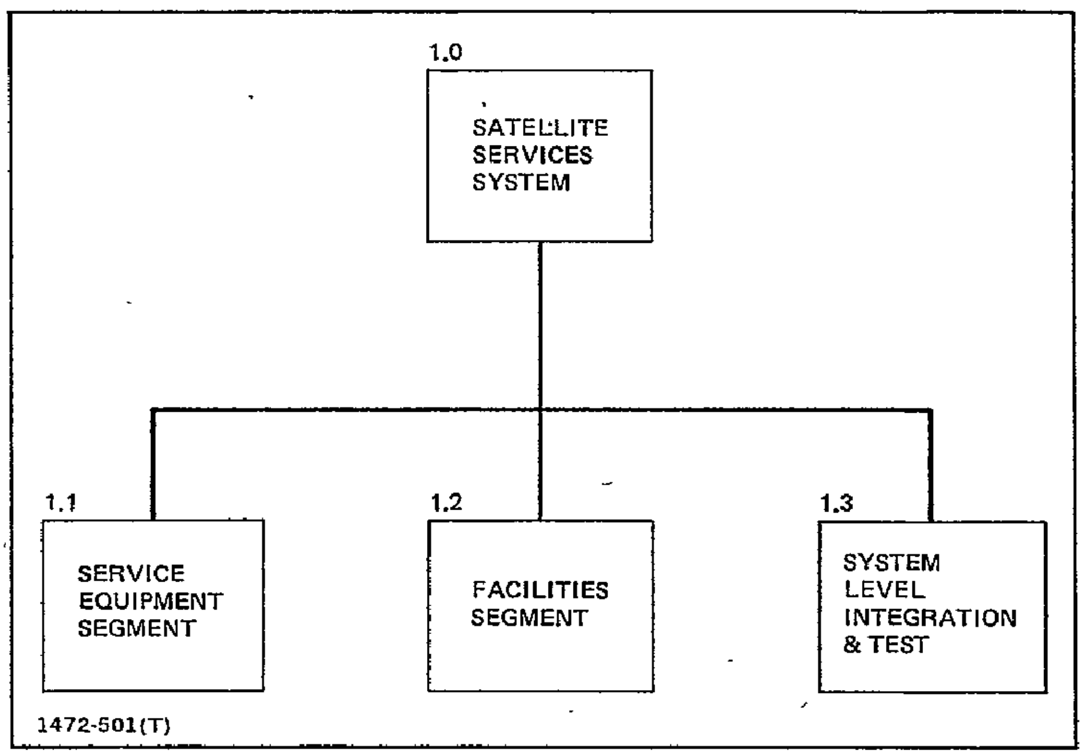

Fig. A-1 Preliminary Top-Level WBS — Satellite Services System

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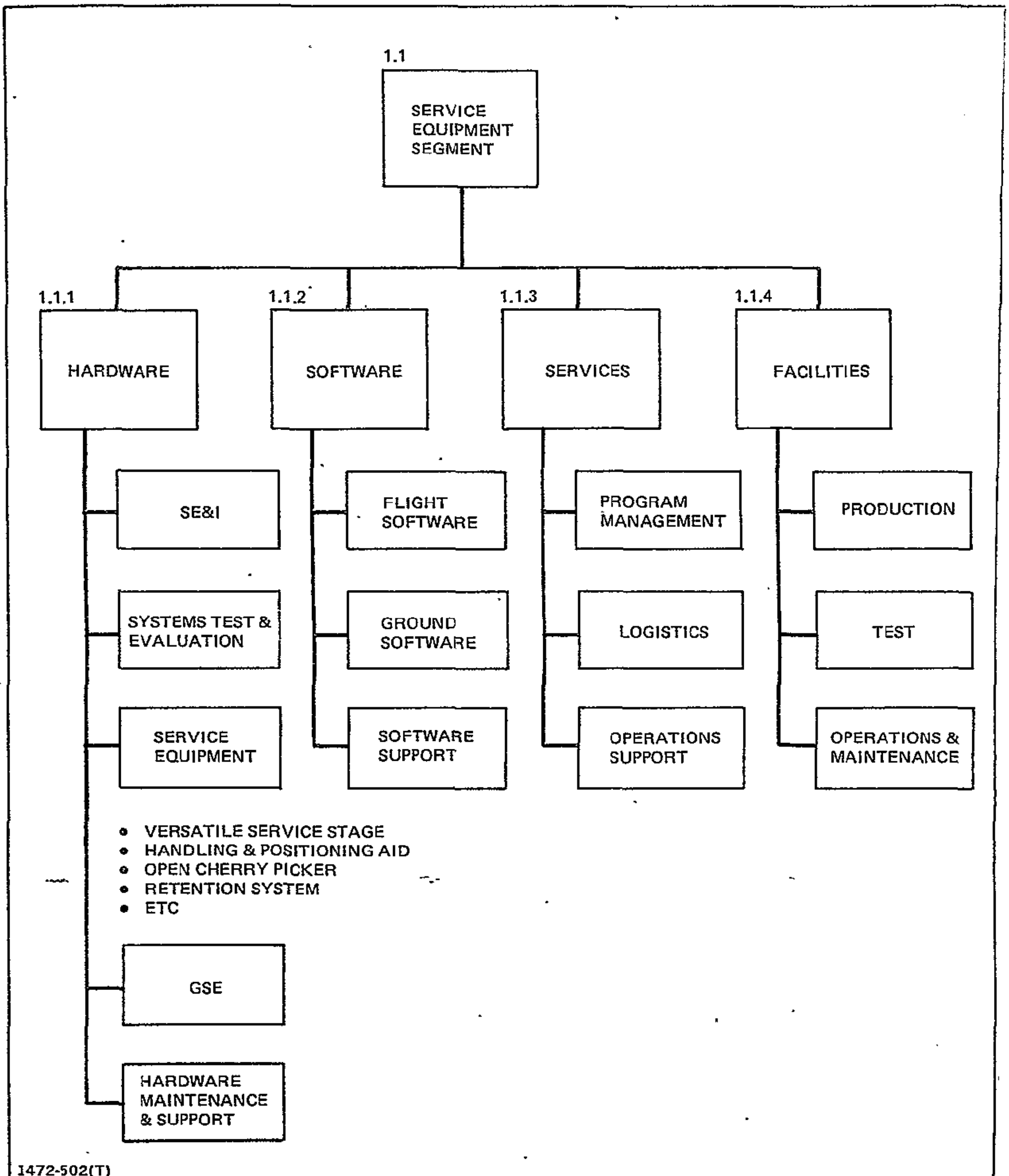

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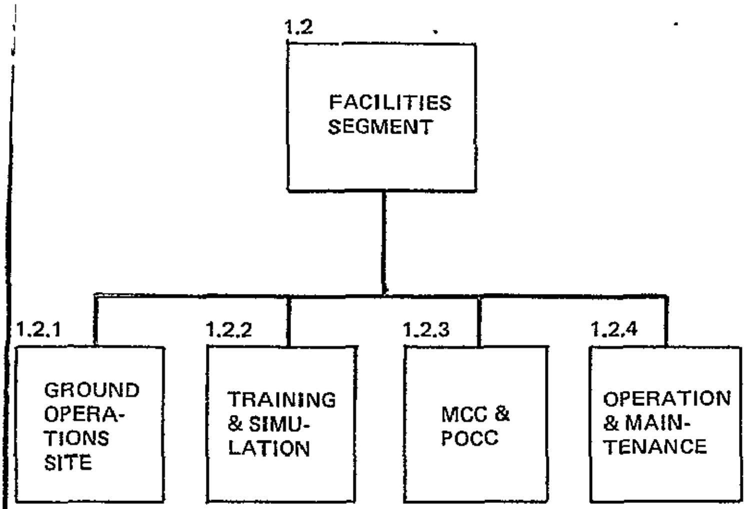
1.2
FACILITIES SEGMENT
1.2.1
GROUND OPERA-TIONS SITE
1.2.2
TRAINING & SIMU-LATION
1.2.3
MCC & POCC
1.2.4
OPERATION & MAIN-TENANCE

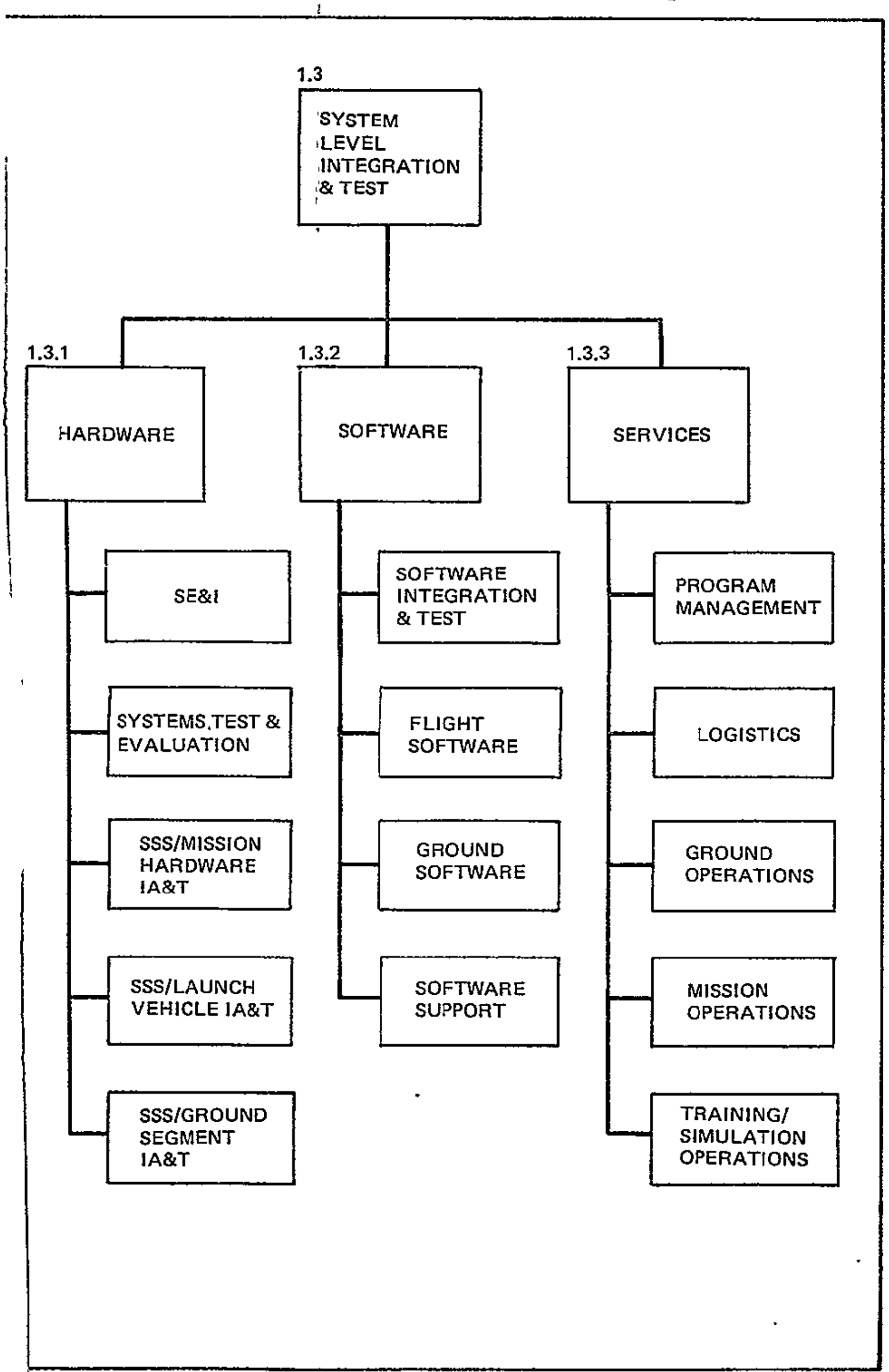

Fig. A-2 Preliminary WBS — Satellite Services System

1.1 SERVICE EQUIPMENT SEGMENT

The Service Equipment segment encompasses hardware, software, services, and facilities that are required to develop, produce, operate, and maintain Satellite Services equipment.

1.1.1 Hardware

This category includes systems engineering and integration for Satellite Services equipment; systems test and evaluation (including hardware integration, assembly, and test); analysis, design, fabrication, assembly, and test of flight hardware and GSE; design and fabrication of tooling/STE; fabrication of spares; and maintenance of production STE/tooling.

1.1.1.1 Systems Engineering & Integration (SE&I) - includes the requirements analysis; interface definition; integrated equipment design, analysis, and modeling; mass properties, loads and dynamics, thermal performance, and contamination analyses; verification definition; safety, reliability, maintainability, configuration management, and quality engineering for the equipment. Hardware/software integration is also included as well as system engineering in support of production.

1.1.1.2 Systems Test & Evaluation - includes planning and performance of system level ground tests of Satellite Services equipment necessary to evaluate and verify hardware integrity and performance. System level testing includes development test, qualification test and integration, assembly, and acceptance test of SSS flight equipment. Test article and instrumentation as well as test program costs are included.

1.1.1.3 Service Equipment - covers design, development, tooling, and production of subsystem hardware and initial spares. Service equipment includes:

- Versatile Service Stage
- Handling and Positioning Aid
- Open Cherry Picker
- Retention Systems
- Etc.

Preceding page blank

For each item of service equipment noted, cost and technical programmatic data are correlated, as applicable, to the following generic subsystem hardware:

- Structures
- Mechanisms
- Thermal control
- Primary propulsion
- Attitude control propulsion
- Ordnance
- Electrical power
- Guidance, navigation & control (GN&C)
- Tracking, telemetry & command (TT&C)
- Communications
- Data management
- Instrumentation
- Crew accommodations
- Environmental control/life support (ECLS).

All equipment costs required to perform the Satellite Service functions (e.g., Versatile Service Stage) include the labor and material necessary to design, develop, manufacture, assemble, test, and deliver the applicable subsystem hardware. These costs are estimated and presented within the generic categories noted above. Costs also include the design, fabrication/purchase of test specimens and test equipment; the preparation of engineering drawings, procedures, and specifications; supplier qualification and coordination; design and fabrication of tooling; and development/qualification test as well as acceptance testing.

1.1.1.4 Ground Support Equipment (GSE) - covers labor and material required to design, manufacture, procure, assemble, test, and deliver all GSE hardware for Satellite Service equipment transportation/handling, final assembly checkout, development/verification test, ground and mission operations support, and training/simulation. GSE includes electrical/mechanical/hydraulic equipment required for Satellite Services equipment test/checkout, fault isolation, handling, transportation, servicing, and repair, as well as the initial spares for this equipment.

1.1.1.5 Hardware Maintenance & Support - covers hardware-related factory support of operational phase activities. Production of operational spares for flight equipment and GSE, factory refurbishment of flight hardware, and maintenance of factory tooling/ test equipment are included.

1.1.2 Software

This category includes all software effort associated with the development, production, and operational support of computer programs for Satellite Services equipment.

1.1.2.1 Flight Software - covers preparation of the software requirements document; design/development of the algorithm; coding, test/validation, and documentation of specific flight equipment computer programs.

1.1.2.2 Ground Software - covers preparation of the software requirements document; design/development of the algorithm; coding, test/validation, and documentation of specific computer programs required for GSE support of flight equipment checkout/ test, ground operations, and mission operations.

1.1.2.3 Software Support - consists of all sustaining Satellite Services equipment software activity in the operations phase. Software troubleshooting, mission-peculiar program modifications, and software documentation/control are included.

1.1.3 Services

This category includes Satellite Services equipment activities that are not end-item or systems engineering-oriented. Program management, logistics, and ground/mission operations support are included.

1.1.3.1 Program Management - covers management activities such as planning, organizing, directing, coordinating, controlling, and approving actions required for the development, production, and operations activity of Satellite Services equipment. The program manager, administrative staff, cost/performance management, contract administration, subcontract management, material procurement, and manufacturing planning personnel are included.

1.1.3.2 Logistics - covers the establishment and operation of a logistics system for Satellite Services equipment flight hardware and related GSE. Included is preparation for and transportation of equipment with special requirements due to size, weight, shape, or the need for a controlled environment. When these charges are indirect,

transportation of hardware items that do not require special consideration will be excluded. Provisioning, warehousing, and control of flight hardware and GSE spares are included herein.

1.1.3.3 Operations Support - covers all effort associated with Satellite Services equipment operational support. It includes facility/GSE activation for service equipment production and test as well as equipment support for system ground and mission operations.

1.1.4 Facilities

This category includes acquisition and operations costs for the construction (or modification) and operation of facilities required for Satellite Services equipment production, test, and operations support. Facility/GSE activation is excluded since it is covered in the Operations Support WBS, Subsection 1.1.3.3.

1.1.4.1 Production - covers acquisition of production facilities for Satellite Services System flight hardware and GSE. New construction or modification of existing production facilities are included. These costs encompass only "brick and mortar" type expenditures for plant, office, specialty areas and their associated utilities, but they do include planning, design, procurement, fabrication, and assembly activities for these facilities.

1.1.4.2 Test - covers acquisition of facilities for development, qualification, and acceptance testing of SSS flight hardware and GSE. It includes new construction or modification of existing test facilities. These costs encompass only "brick and mortar" type expenditures for building, test stands, chambers, office areas and their associated utilities, but they do include planning, design, procurement, fabrication, and assembly activities for these facilities.

1.1.4.3 Facilities Operation & Maintenance - covers operation and maintenance of Satellite Services equipment production and test facilities for the operations phase of the SSS program. The operation and maintenance activity covers only the basic facility and excludes service equipment/GSE operations activity included in the Hardware Maintenance and Support WBS, Subsection 1.1.1.5.

1.2 FACILITIES SEGMENT

The Facilities Segment encompasses acquisition and operation costs for the construction (or modification) and operation of facilities required for SSS ground operations, mission operations, and training/simulation. Facility/GSE activation is excluded since it is covered in the Services WBS, Subsections 1.3.3.3 through 1.3.3.5.

1.2.1 Ground Operations Site

This category covers the acquisition of facilities for pre- and post-launch SSS ground operations. These costs encompass only "brick and mortar" type expenditures for checkout, maintenance, offices and their associated utilities. Planning, design, procurement, fabrication, and assembly activities for these facilities are also included.

1.2.2 Training & Simulation

This category covers the acquisition of training and simulation facilities for the training of flight personnel and the evaluation of SSS mission operations. Planning, design, manufacture, procurement, and assembly of these facilities ("brick and mortar" type expenditures only) are also included.

1.2.3 MCC & POCC

This category covers the acquisition of Mission Control Center (MCC) and Payload Operations Control Center (POCC) facilities for Satellite Services System mission operations. These costs encompass only "brick and mortar" type expenditures for mission control and support. Planning, design, procurement, fabrication, and assembly activities for these facilities are also included.

1.2.4 Operation & Maintenance

This category covers operation and maintenance operations and training/simulation facilities for the operations phase of the SSS program. The operations and maintenance activity covers only the basic facility and excludes service equipment/GSE and trainer/simulators operations activity contained in the Ground Operations, Mission Operations, Training/Simulation Operations WBS, Subsections 1.3.3.3 through 1.3.3.5.

1.3 SYSTEM LEVEL INTEGRATION & TEST

System Level Integration and Test encompasses system engineering; system-level integration, test, and software; as well as the services required to develop, produce, operate, and maintain the Satellite Services System.

1.3.1 Hardware

This category includes system engineering, integration, and testing for the Satellite Services System. It also includes the integration and test of this system, from a development/qualification viewpoint, with mission hardware, launch vehicle, and ground segment.

1.3.1.1 Systems Engineering & Integration (SE&I) - covers the effort required for systems engineering and integration of the Satellite Services System. It includes the requirements analysis; interface definition; integrated system design, analysis, and modeling; mass properties, loads and dynamics, thermal performance, and contamination analysis; verification definition; and safety, reliability, maintainability, configuration management, and quality engineering for this system. Hardware/software integration is also included along with systems engineering support of production.

1.3.1.2 Systems Test & Evaluation - covers the effort required to plan and perform the system level ground tests of Satellite Services equipment necessary to evaluate and verify hardware capability and performance. This systems level testing includes development and qualification tests essential to SSS verification. Test article and instrumentation as well as test program costs are included.

1.3.1.3 SSS/Mission Hardware IA&T - covers integration, assembly, and testing of the Satellite Services System and mission hardware. This is an acquisition phase activity that includes analysis of applicable Satellite Services equipment/mission hardware compatibility and integration/test of applicable hardware for interface compatibility verification.

1.3.1.4 SSS/Launch Vehicle IA&T - covers integration, assembly, and testing of the Satellite Services System and Launch Vehicle. This is an acquisition phase activity that includes analysis of applicable Satellite Services equipment/Launch Vehicle compatibility and integration/test of applicable hardware for interface compatibility verification.

1.3.1.5 SSS/Ground Segment IA&T - covers integration, assembly, and testing of the Satellite Services System and the Ground Segment. This is an acquisition phase activity that includes analysis of applicable Satellite Services equipment/Ground Segment compatibility and integration/testing of applicable hardware for interface compatibility verification. The Ground Segment interface includes the MCC, POCC, and TDRS elements.

1.3.2 Software

This category includes the development, production, and operational support of system-level computer programs for Satellite Services System flight and ground operations.

1.3.2.1 Software Integration & Test - covers the systems level effort for SSS computer software. Software management and control, internal and external interface control, and integrated systems tests are also included. Hardware/software integration is excluded since it is included in the SE&I WBS, Subsection 1.3.1.1.

1.3.2.2 Flight Software - covers the preparation of the software requirements document, design/development of the algorithm; and coding, testing/validation, as well as documentation of specific flight system computer programs.

1.3.2.3 Ground Software - covers the preparation of the software requirements document, design/development of the algorithm; and coding, test/validation, as well as documentation of specific computer programs required for GSE support of flight system checkout/testing, ground operations, and mission operations.

1.3.2.4 Software Support - consists of all sustaining SSS software activity in the operations phase. It includes software troubleshooting, mission-peculiar program modifications, and software documentation/control.

1.3.3 Services

This category includes SSS activities that are not end-item or systems engineering oriented. Program management, logistics, and ground/mission operations, including training/simulation are also included.

1.3.3.1 Program Management - includes planning, organizing, directing, coordinating, controlling, and approving actions required for the development, production, and operations phases of the program. The program manager, administrative staff, cost/performance management, contract administration, subcontract management, material procurement and program planning personnel are included.

1.3.3.2 Logistics - covers the establishment and operation of a logistics system for SSS flight hardware and related GSE. Provisioning, warehousing, and controlling flight hardware as well as GSE spares are included.

1.3.3.3 Ground Operations - covers planning, coordination, and implementation of launch site activities for the Satellite Services System. It includes activation of launch site facilities/GSE, initial checkout of flight hardware, integration of flight hardware with the STS and payload, and launch support. In addition, post-flight safing and inspection, maintenance and field site refurbishment, and revalidation/functional checkout of flight hardware for subsequent mission operations are included. Tasks covered in this effort are: development of requirements, ground operations planning, coordination of schedules, preparation of procedures, and liaison between equipment suppliers and field site as well as hardware related checkout and maintenance activities.

1.3.3.4 <u>Mission Operations</u> - covers planning for and support of mission operations utilizing SSS flight hardware. Control/scheduling of flight hardware utilization, development of timeline inputs for mission operations procedures, preparation of procedures for flight hardware mission operation, activation of facilities/GSE for mission support, and real-time ground support of mission operations are included.

1.3.3.5 <u>Training/Simulation Operations</u> - covers planning for and support of training and simulation operations for the Satellite Services System. It includes the training of flight personnel and the evaluation of mission operations for SSS functions. This activity encompasses the development of training/simulation requirements, preparation of schedules, activation of training/simulation facilities, and the preparation of manuals, procedures and any other aids required for training/simulation programs.

Appendix B

Equipment Utilization Summary

Table of Contents

Table of Contents (Contd)

B1 – INITIAL LAUNCH – EQUIPMENT UTILIZATION SUMMARY – DIRECT DELIVERY/SERVICING SATELLITE MISSIONS ('83 TO '85)
RMS PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT											OPTIONAL EQUIPMENT			
	RETENTION STRUCTURE	TILT TABLE	SPIN TABLE	RMS	PIDA	MFR/RMS	MMU/WRU		HPA	MTV	VSS	SUN SHIELD	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCEMENT
1983 MISSIONS							WITH END EFFECTOR	WITH STABILIZER							
SPAS-01 STS PALLET SAT	X			X		X	X	X^2							
1984 MISSIONS															
SPACE TELESCOPE (A-3)		X		X		X	X	X							
LDEF (01-10)	X			X		X	X	X^2							
OPTIONAL SERVICE MISSIONS												X	X	X	X
1985 MISSIONS															
SPAS-01 STS PALLET SAT.	X			X		X	X	X^2							
GRO-GAMMA RAY OBSERV (A-7)	X			X		X	X	X^2							

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1472-503(T)

NOTE: EXPONENT INDICATES NUMBER OF USES

B2 – INITIAL LAUNCH – EQUIPMENT UTILIZATION SUMMARY – DIRECT DELIVERY/SERVICING SATELLITE MISSIONS ('86 TO '88)
HPA PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT												OPTIONAL EQUIPMENT		
	RETENTION STRUCTURE	TILT TABLE	SPIN TABLE	RMS	PIDA	MFR/RMS	MMU/WRU		HPA	MTV	VSS	SUN SHIELD	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCEMENT
							WITH END EFFECTOR	WITH STABILIZER							
1986 MISSIONS															
LDEF (01-10)	X			X		X	X	X	X						
SASP-SCI & APP SP PLAT (U-7 & L-2)	X			X		X	X	X	X						
25kW PWR MOD (U 8)	X			X	X	X	X	X	X						
LG STRUCT CONSTR (U 6)	X			X		X	X	X	X						
MAT'LS EXPERIMENT CARRIER (U-9 & -10)	X			X		X	X	X	X						
SUBSAT FACILITY (S-9)	X			X		X	X	X	X						
OPTIONAL SERVICE MISSIONS												X	X		X
1987 MISSIONS															
SPAS-01 STS PALLET SAT	X			X		X	X	X	X						
MAT'LS EXPERIMENT CARRIER (U-9 & -10)	X			X		X	X	X	X						
SUBSAT FACILITY (S 9)	X			X		X	X	X	X						
AXAF-ADV X-RAY ASTRO (A-9)				X	X	X	X	X	X						
CRO-COSMIC RAY OBSER (A-13)	X			X		X	X	X	X						
GRAVITY PROBE B (A 8)	X			X		X	X	X	X						
POLAIRE (LEP)	X			X		X	X	X	X						
COASTAL SAT. (NAS)	X			X		X	X	X	X						
SOC-SP OPS CTR (5 YR)				X^2	X^2	X^2	X^2	X^2	X^2						
OPTIONAL SERVICE MISSIONS												X^2	X^2		X^2
1988 MISSIONS															
SASP-SCI & APP SP PLAT (U-7 & L-2)	X			X		X	X	X	X						
25 kW PWR MOD (U-8)				X	X	X	X	X	X						
MAG FIELD SURV B(R-7)	X			X		X	X	X	X						
MAT'LS EXPERIMENT CARRIER (U-9 & -10)	X			X		X	X	X	X						
SUBSAT FACILITY (S-9)	X			X		X	X	X	X						
SOC-SP OPS CTR (5 YR.)				X^2	X^2	X^2	X^2	X^2	X^2						
OPTIONAL SERVICE MISSIONS												X^2	X^2		X^2

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1472-504(T)

NOTE: EXPONENT INDICATES NUMBER OF USES

B3 – INITIAL LAUNCH – EQUIPMENT UTILIZATION SUMMARY – DIRECT DELIVERY/SERVICING SATELLITE MISSIONS ('89 TO '92)
HPA PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT											OPTIONAL EQUIPMENT			
	RETENTION STRUCTURE	TILT TABLE	SPIN TABLE	RMS	PIDA	MFR/RMS	MMU/WRU WITH END EFFECTOR	MMU/WRU WITH STABILIZER	HPA	MTV	VSS	SUN SHIELD	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCEMENT
1989 MISSIONS															
SPAS-01 STS PALLET SAT.	X			X		X	X	X	X						
LDEF (01-10)	X			X		X	X	X	X						
MAT'LS EXPERIMENT CARRIER (U-9 & -10)	X			X		X	X	X	X						
SUBSAT FACILITY (S-9)	X			X		X	X	X	X						
SOC-SP OPS CTR (5 YR)				X	X	X	X	X	X						
OCEAN RESEARCH SAR (E-11)				X	X	X	X	X	X						
HVY NUCLI EXPL (GSF)	X			X		X	X	X	X						
OPTIONAL SERVICE MISSIONS												X	X		X
1990 MISSIONS															
SPACE TELESCOPE (A-3)		X		X		X	X	X	X						
MAT'LS EXPERIMENT CARRIER (U-9 & -10)	X			X		X	X	X	X						
SUBSAT FACILITY (S-9)	X			X		X	X	X	X						
SOC-SP OPS CTR (5 YR)				X^2	X^2	X^2	X^2	X^2	X^2						
LG SOLAR OBSERV (LEP)				X	X	X	X	X	X						
OPTIONAL SERVICE MISSIONS												X	X		X
1991 MISSIONS															
SPAS-01 STS PALLET SAT.	X			X		X	X	X	X						
25kW PWR MOD. (U-8)				X	X	X	X	X	X						
MAT'LS EXPERIMENT CARRIER (U-9 & -10)	X			X		X	X	X	X						
SUBSAT FACILITY (S-9)	X			X		X	X	X	X						
AXAF-ADV X-RAY ASTRO (A-9)				X	X	X	X	X	X						
CRO-COSMIC RAY OBSER (A-13)	X			X		X	X	X	X						
SOLAR TERR OBS (S-12)	X			X		X	X	X	X						
ADVANCED RELATIVITY (LEP)	X^2			X^2		X^2	X^2	X^2	X^2						
OPTIONAL SERVICE MISSIONS												X^2	X^2		X^2
1992 MISSIONS															
MAT'LS EXPERIMENT CARRIER (U-9 & -10)	X			X		X	X	X	X						
POLAIRE (LEP)	X			X		X	X	X	X						
SPS TEST ARTICLE (MDC) (U-13)				X^2	X^2	X^2	X^2	X^2	X^2						
AMBIENT DEPLOY. IR TELE (A-17)				X	X	X	X	X	X						
OPTIONAL SERVICE MISSIONS												X	X		X

R81-1108-071D-074D
1472-505(T)

NOTE: EXPONENT INDICATES NUMBER OF USES

B4 – INITIAL LAUNCH – EQUIPMENT UTILIZATION SUMMARY – DIRECT DELIVERY/SERVICING SATELLITE MISSIONS ('93)
HPA PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT											OPTIONAL EQUIPMENT			
1993 MISSIONS	RETENTION STRUCTURE	TILT TABLE	SPIN TABLE	RMS	PIDA	MFR/RMS	MMU/WRU WITH END EFFECTOR	MMU/WRU WITH STABILIZER	HPA	MTV	VSS	SUN SHIELD	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCEMENT
SPAS-01 STS PALLET SAT.	X			X		X	X	X	X						
LDEF (01-10)	X			X		X	X	X	X						
25kW PWR MOD. (U-8)				X	X	X	X	X	X						
MAT'LS EXPERIMENT CARRIER (U-9 & -10)	X			X		X	X	X	X						
SPS TEST ARTICLE (MDC) (U-13)				X^2	X^2	X^2	X^2	X^2	X^2						
IR INTERFEROMETER (A-18)				X	X	X	X	X	X						
OPTIONAL SERVICE MISSIONS												X^2	X^2		X^2

R81-1108-075D
1472-506(T)

NOTE: EXPONENT INDICATES NUMBER OF USES

B5 – INITIAL LAUNCH – EQUIPMENT UTILIZATION SUMMARY – LEO/PROPULSION SATELLITE MISSIONS ('83 TO '86)
RMS PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT											OPTIONAL EQUIPMENT			
1983 MISSIONS	RETENTION STRUCTURE	TILT TABLE	SPIN TABLE	RMS	PIDA	MFR/RMS	MMU/WRU WITH END EFFECTOR	MMU/WRU WITH STABILIZER	HPA	MTV	VSS	SUN SHIELD	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCEMENT
LANDSAT D (R-2)	X	X		X		X	X	X^2		X					
CHEM REL MODULE (S-5)	X	X		X		X	X	X^2		X					
1984 MISSIONS															
ERBS – EARTH RAD BUDGET SAT. (E-4)	X	X		X		X	X	X^2		X					
LANDSAT D'' (5 YR)	X	X		X		X	X	X^2		X					
NOAA (E-5)	X	X		X		X	X	X^2		X					
OPTIONAL SERVICE MISSIONS												X	X	X	X
1985 MISSIONS															
CHEM REL MODULE (S-5)	X	X		X		X	X	X^2		X					
LANDSAT D''' (5 YR)	X	X		X		X	X	X^2		X					
COBE – COSMIC BKGND EXPL (GSF)	X	X		X		X	X	X^2		X					
GRAVSAT (R-4, GSF)	X^2	X^2		X^2		X^2	X^2	X^4		X^2					
STS – 46															
STS – 49															
OPTIONAL SERVICE MISSIONS												X	X	X	X
1986 MISSIONS	HPA PRIME USAGE														
NOAA (E-5)	X			X		X	X	X^2	X	X					
EUVE-EXTREME UV EXPLORER (A-5, GSF)	X			X		X	X	X^2	X	X					
REGION H20 QUAL MON (LEP)	X			X		X	X	X^2	X	X					
ORBITER CAMERA FR FLYER (MML)	X			X		X	X	X^2	X	X					
UARS UPPER ATMOS RES (E-7)	X			X		X	X	X^2	X	X					
NOSS-NAT OCEAN SAT. (E-6)	X			X		X	X	X^2	X	X					
MAGSAT B (R-1)	X			X		X	X	X^2	X	X					
HI ENERGY EXPL (NAS)	X			X		X	X	X^2	X	X					
ASTROPHYSICS EXPL (GSF)	X			X		X	X	X^2	X	X					
X-RAY TIME EXPL (A-10, GSF)	X			X		X	X	X^2	X	X					
ICEX-ICE & CLIM EXP (5 YR)	X			X		X	X	X^2	X	X					
OP LAND OBSER SYS (LEP) (R-5)	X			X		X	X	X^2	X	X					
OPTIONAL SERVICE MISSIONS												X^2	X^2		X^2

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NOTE: EXPONENT INDICATES NUMBER OF USES

B6 – INITIAL LAUNCH – EQUIPMENT UTILIZATION SUMMARY – LEO/PROPULSION SATELLITE MISSIONS ('87 TO '89)
HPA PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT											OPTIONAL EQUIPMENT			
	RETENTION STRUCTURE	TILT TABLE	SPIN TABLE	RMS	PIDA	MFR/RMS	MMU/WRU WITH END EFFECTOR	MMU/WRU WITH STABILIZER	HPA	MTV	VSS	SUN SHIELD	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCEMENT
1987 MISSIONS															
ERBS – EARTH RAD BUDGET SAT. (E-4)	X			X		X	X	X^2	X	X	X				
NOAA (E-5)	X			X		X	X	X^2	X	X	X				
UARS-UPPER ATMOS RES (E-7)	X			X		X	X	X^2	X	X	X				
NOSS-NAT OCEAN SAT. (E-6)	X			X		X	X	X^2	X	X	X				
OP LAND OBSER SYS (LEP) (R-5)	X			X		X	X	X^2	X	X	X				
TOPEX-TOPOG EXP OCEAN CIRCULATION (E-9)	X			X		X	X	X^2	X	X	X				
SOIL MOISTURE (R-8)	X			X		X	X	X^2	X	X	X				
ALL WEATHER MICROWAVE (LEP)	X			X		X	X	X^2	X	X	X				
EARTH SURVEY (LEP)	X			X		X	X	X^2	X	X	X				
OPTIONAL SERVICE MISSIONS												X^2	X^2		X^2
1988 MISSIONS															
ORBITER CAMERA FR FLYER (MML)	X			X		X	X	X^2	X	X	X				
NOSS NAT OCEAN SAT (E-6)	X			X		X	X	X^2	X	X	X				
OP LAND OBSER SYS (LEP) (R-5)	X			X		X	X	X^2	X	X	X				
SCADM-SOLAR CYCLES & DYNAMICS MISS (S-13)	X			X		X	X	X^2	X	X	X				
ADV GEOLOGY SAT. (LEP)	X			X		X	X	X^2	X	X	X				
GLOBAL REGIONAL ATHMOS MONITOR (LEP)	X			X		X	X	X^2	X	X	X				
LAMAR-LG AREA MOD ARRAY (A-14, GSF)	X			X		X	X	X^2	X	X	X				
PRIV EARTH RES (LEP)	X			X		X	X	X^2	X	X	X				
ATMAS-ADV THERM MAP (R-6)	X			X		X	X	X^2	X	X	X				
VLBI-V, VLG BASE INT (A-15)	X			X		X	X	X^2	X	X	X				
OPTIONAL SERVICE MISSIONS												X^2	X^2		X^2
1989 MISSIONS															
NOSS-NAT OCEAN SAT. (E-6)	X			X		X	X	X^2	X	X	X				
X-RAY TIME EXPL (A-10, GSF)	X			X		X	X	X^2	X	X	X				
ICEX-ICE & CLIM EXP (5 YR)	X			X		X	X	X^2	X	X	X				
EARTH SURVEY (LEP)	X			X		X	X	X^2	X	X	X				
VLBI-V, LG BASE INT (A-15)	X			X		X	X	X^2	X	X	X				
GAMMA-RAY TRANSIENT EXPL (GSF)	X			X		X	X	X^2	X	X	X				
ENVIRON MONITOR (LEP)	X			X		X	X	X^2	X	X	X				
OP METEOROLOGY (E-10)	X			X		X	X	X^2	X	X	X				
ASTRONOMY (MDC)	X			X		X	X	X^2	X	X	X				
UV PHOTOMET/POLARIMET EXPL (GSF)	X			X		X	X	X^2	X	X	X				
X-RAY OBSERVATORY (GSF)	X			X		X	X	X^2	X	X	X				
OPTIONAL SERVICE MISSIONS												X^2	X^2		X^2

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NOTE EXPONENT INDICATES NUMBER OF USES

B7 – INITIAL LAUNCH – EQUIPMENT UTILIZATION SUMMARY – LEO/PROPULSION SATELLITE MISSIONS ('90 TO '93)
HPA PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT											OPTIONAL EQUIPMENT			
	RETENTION STRUCTURE	TILT TABLE	SPIN TABLE	RMS	PIDA	MFR/RMS	MMU/WRU		HPA	MTV	VSS	SUN SHIELD	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCEMENT
							WITH END EFFECTOR	WITH STABILIZER							
1990 MISSIONS															
GRAVSAT (R-4, GSF)	X^2			X^2		X^2	X^2	X^4	X^2	X^2	X^2				
OP LAND OBSER SYS (LEP) (R-5)	X			X		X	X	X^2	X	X	X				
SOIL MOISTURE (R-8)	X			X		X	X	X^2	X	X	X				
ATMAS-ADV THERM MAP (R-6)	X			X		X	X	X^2	X	X	X				
SOFT X-RAY SURVEY (GSF)	X			X		X	X	X^2	X	X	X				
MOLECULAR LINE SURVEY (GSF)	X			X		X	X	X^2	X	X	X				
X-RAY SPECTROSCOPY (GSF)	X			X		X	X	X^2	X	X	X				
OPTIONAL SERVICE MISSIONS												X^2	X^2		X^2
1991 MISSIONS															
ERBS – EARTH RAD BUDGET SAT. (E-4)	X			X		X	X	X^2	X	X	X				
OP LAND OBSER SYS (LEP) (R-5)	X			X		X	X	X^2	X	X	X				
SCADM-SOLAR CYCLES & DYNAMICS MISS. (S-13)	X			X		X	X	X^2	X	X	X				
EARTH SURVEY (LEP)	X			X		X	X	X^2	X	X	X				
ENVIRON MONITOR (LEP)	X			X		X	X	X^2	X	X	X				
OPTIONAL SERVICE MISSIONS												X	X		X
1992 MISSIONS															
NOSS-NAT OCEAN SAT (E-6)	X			X		X	X	X^2	X	X	X				
OP LAND OBSER SYS (LEP) (R-5)	X			X		X	X	X^2	X	X	X				
ALL WEATHER MICROWAVE (LEP)	X			X		X	X	X^2	X	X	X				
GLOBAL REGIONAL ATHMOS MONITOR (LEP)	X			X		X	X	X^2	X	X	X				
PRIV EARTH RES (LEP)	X			X		X	X	X^2	X	X	X				
X-RAY OBSERVATORY (GSF)	X			X		X	X	X^2	X	X	X				
SUBMILLIMETER TELESCOPE (A-16)	X			X		X	X	X^2	X	X	X				
OPTIONAL SERVICE MISSIONS												X^2	X^2		X^2
1993 MISSIONS															
NOSS-NAT OCEAN SAT. (E-6)	X			X		X	X	X^2	X	X	X				
SOIL MOISTURE (R-8)	X			X		X	X	X^2	X	X	X				
EARTH SURVEY (LEP)	X			X		X	X	X^2	X	X	X				
ADV GEOLOGY SAT. (LEP)	X			X		X	X	X^2	X	X	X				
OPTIONAL SERVICE MISSIONS												X	X		X

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NOTE EXPONENT INDICATES NUMBER OF USES

B8 – INITIAL LAUNCH – EQUIPMENT UTILIZATION SUMMARY – GEO SATELLITE MISSIONS ('83 TO '85)
RMS PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT											OPTIONAL EQUIPMENT			
	RETENTION STRUCTURE	TILT TABLE	SPIN TABLE	RMS	PIDA	MFR/RMS	MMU/WRU		HPA	MTV	VSS	SUN SHIELD	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCEMENT
1983 MISSIONS							WITH END EFFECTOR	WITH STABILIZER							
TDRS (C-1 & MDC)	X^2	X^2		X^2		X^2	X^2	X^2		X^2					
INTELSAT (AVN)	X	X	X	X		X	X	X		X					
TELESAT (AVN)	X		X	X		X	X	X		X					
SAT. BUS. SYS (MDC & AVN)	X		X	X		X	X	X		X					
RCA (AVN)	X		X	X		X	X	X		X					
INSAT (AVN & MDC)	X^2		X^2	X^2		X^2	X^2	X^2		X^2					
OPTIONAL SERVICE MISSIONS												X	X	X	X
													X	X	X
1984 MISSIONS															
TDRS (C-1 & MDC)	X	X		X		X	X	X		X					
INTELSAT (AVN)	X	X	X	X		X	X	X		X					
TELESAT (AVN)	X^2		X^2	X^2		X^2	X^2	X^2		X^2					
RCA (AVN)	X^2		X^2	X^2		X^2	X^2	X^2		X^2					
PALAPA (AVN)	X^2		X^2	X^2		X^2	X^2	X^2		X^2					
SYNCOM-IV (LEASAT, DoD)	X^3	X^3		X^3		X^3	X^3	X^3		X^3					
ARABSAT (AVN)	X^2		X^2	X^2		X^2	X^2	X^2		X^2					
AT&T (AVN)	X^2		X^2	X^2		X^2	X^2	X^2		X^2					
OPTIONAL SERVICE MISSIONS												X	X	X	X
													X	X	X
													X	X	X
1985 MISSIONS															
TDRS (C-1 & MDC)	X	X		X		X	X	X		X					
INTELSAT (AVN)	X	X	X	X		X	X	X		X					
TELESAT (AVN)	X		X	X		X	X	X		X					
SAT BUS. SYS (MDC & AVN)	X		X	X		X	X	X		X					
RCA (AVN)	X		X	X		X	X	X		X					
SYNCOM-IV (LEASAT, DoD)	X^2	X^2		X^2		X^2	X^2	X^2		X^2					
AT&T(AVN)	X		X	X		X	X	X		X					
FOR. COMM/SBS (MDC)	X^2		X^2	X^2		X^2	X^2	X^2		X^2					
INMARSAT (MDC)	X		X	X		X	X	X		X					
GLOBAL DISASTER COMM (MDC)	X		X	X		X	X	X		X					
PEOP REP CHINA (AVN)	X		X	X		X	X	X		X					
OPTIONAL SERVICE MISSIONS													X	X	X
													X	X	X
													X	X	X

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NOTE. EXPONENT INDICATES NUMBER OF USES

B9 – INITIAL LAUNCH – EQUIPMENT UTILIZATION SUMMARY – GEO SATELLITE MISSIONS ('86, '87)
HPA PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT: RETENTION STRUCTURE	TILT TABLE	SPIN TABLE	RMS	PIDA	MFR/RMS	MMU/WRU: WITH END EFFECTOR	MMU/WRU: WITH STABILIZER	HPA	MTV.	VSS	OPTIONAL EQUIPMENT: SUN SHIELD	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCEMENT
1986 MISSIONS															
INTELSAT (AVN)	X^2		X^2	X^2		X^2	X^2	X^2	X^2	X^2					
FOR. COMM/SBS (MDC)	X^4		X^4	X^4		X^4	X^4	X^4	X^4	X^4					
INMARSAT (MDC)	X^2		X^2	X^2		X^2	X^2	X^2	X^2	X^2					
PEOP REP CHINA (AVN)	X		X	X		X	X	X	X	X					
GOES GEO ORB ENV SAT. (E-2)	X		X	X		X	X	X	X	X					
30/20 GHz ANT. TRUNK (C-4)	X		X	X		X	X	X	X	X					
SEPS-SOL ELECT PROP. (T-9)	X			X		X	X	X	X	X					
RESOURCES/POL'N/WEATH/COMM (MDC)	X		X	X		X	X	X	X	X					
FOREIGN COMM (MDC)	X		X	X		X	X	X	X	X					
EARTH OBS/COMMUN (MDC)	X		X	X		X	X	X	X	X					
OPTIONAL SERVICE MISSIONS												X	X		X
												X	X		X
												X	X		X
1987 MISSIONS															
INTELSAT (AVN)	X		X	X		X	X	X	X	X					
FOR. COMM/SBS (MDC)	X^2		X^2	X^2		X^2	X^2	X^2	X^2	X^2					
GOES GEO ORB. ENV SAT (E-2)	X		X	X		X	X	X	X	X					
STORMSAT (MDC)	X			X		X	X	X	X	X					
EARTH OBS/COMMUN (MDC)	X		X	X		X	X	X	X	X					
EARTH OBS/COMMUN (MDC)	X		X	X		X	X	X	X	X					
MAP GRAVITY FIELD/COMM (MDC)	X		X	X		X	X	X	X	X					
FOR. COMM/EARTH OBBS (MDC)	X		X	X		X	X	X	X	X					
INMETSAT (MDC)	X		X	X		X	X	X	X	X					
US/FOR. COMM (MDC)	X^2		X^2	X^2		X^2	X^2	X^2	X^2	X^2					
FOREIGN COMM (MDC)	X^3		X^3	X^3		X^3	X^3	X^3	X^3	X^3					
RESOURCES/POL'N/WEATH/COMM (MDC)	X		X	X		X	X	X	X	X					
NATO IV (MDC/DoD)	X			X	X	X	X	X	X	X					
OPTIONAL SERVICE MISSIONS												X	X		X
												X	X		X
												X	X		X

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NOTE: EXPONENT INDICATES NUMBER OF USES

B10 – INITIAL LAUNCH – EQUIPMENT UTILIZATION SUMMARY – GEO SATELLITE MISSIONS ('88, '89)
HPA PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT											OPTIONAL EQUIPMENT			
	RETENTION STRUCTURE	TILT TABLE	SPIN TABLE	RMS	PIDA	MFR/RMS	MMU/WRU		HPA	MTV	VSS	SUN SHIELD	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCEMENT
1988 MISSIONS							WITH END EFFECTOR	WITH STABILIZER							
INTELSAT (AVN)	X^2		X^2	X^2		X^2	X^2	X^2	X^2	X^2					
FOR COMM/SBS (MDC)	X^3		X^3	X^3		X^3	X^3	X^3	X^3	X^3					
30/20 GHz ANT. TRUNK (C-4)	X		X	X		X	X	X	X	X					
INMETSAT (MDC)	X^2		X^2	X^2		X^2	X^2	X^2	X^2	X^2					
FOREIGN COMM (MDC)	X^4		X^4	X^4		X^4	X^4	X^4	X^4	X^4					
RESOURCES/POL'N/WEATH/COMM (MDC)	X		X	X		X	X	X	X	X					
NATO IV (MDC/DoD)	X			X	X	X	X	X	X	X					
US COMM (MDC)	X^5		X^5	X^5		X^5	X^5	X^5	X^5	X^5					
THIN. ROUTE SYS COMM (C-6)	X			X		X	X	XQ	X	X					
RESOURCES/POL'N/WEATH/COMM (MDC)	X		X	X		X	X	X	X	X					
EARTH OBS/COMMUN (MDC)	X		X	X		X	X	X	X	X					
OPTIONAL SERVICE MISSIONS												X	X		X
												X	X		X
												X	X		X
												X	X		X
1989 MISSIONS															
INTELSAT (AVN)	X^2		X^2	X^2		X^2	X^2	X^2	X^2	X^2					
FOR COMM/SBS (MDC)	X^2		X^2	X^2		X^2	X^2	X^2	X^2	X^2					
FOREIGN COMM (MDC)	X		X	X		X	X	X	X	X					
EARTH OBS/COMMUN (MDC)	X		X	X		X	X	X	X	X					
EARTH OBS/COMMUN (MDC)	X		X	X		X	X	X	X	X					
FOR. COMM/EARTH ORBS (MDC)	X		X	X		X	X	X	X	X					
INMETSAT (MDC)	X^4		X^4	X^4		X^4	X^4	X^4	X^4	X^4					
US/FOR. COMM (MDC)	X^2		X^2	X^2		X^2	X^2	X^2	X^2	X^2					
FOREIGN COMM (MDC)	X		X	X		X	X	X	X	X					
RESOURCES/POL'N/WEATH/COMM (MDC)	X^2		X^2	X^2		X^2	X^2	X^2	X^2	X^2					
NATO IV (MDC/DoD)	X			X	X	X	X	X	X	X					
US COMM (MDC)	X		X	X		X	X	X	X	X					
US COMM (MDC)	X		X	X		X	X	X	X	X					
ORBIT TRANS VEH (T-10)	X			X	X	X	X	X	X	X					
SIMUL ASTRON MISSION (G)	X			X		X	X	X	X	X					
INT UV-XPLOR-F/O (G)	X			X		X	X	X	X	X					
X-UV SPECTROSCOPY (G)	X			X		X	X	X	X	X					
OPTIONAL SERVICE MISSIONS												X^5	X^5		X^5

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NOTE: EXPONENT INDICATES NUMBER OF USES

B11 – INITIAL LAUNCH – EQUIPMENT UTILIZATION SUMMARY – GEO SATELLITE MISSIONS ('90, '91)
HPA PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT											OPTIONAL EQUIPMENT			
	RETENTION STRUCTURE	TILT TABLE	SPIN TABLE	RMS	PIDA	MFR/RMS	MMU/WRU		HPA	MTV	VSS	SUN SHIELD	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCEMENT
1990 MISSIONS							WITH END EFFECTOR	WITH STABILIZER							
INTELSAT (AVN)	X^2		X^2	X^2		X^2	X^2	X^2	X^2	X^2					
FOR COMM/SBS (MDC)	X^5		X^5	X^5		X^5	X^5	X^5	X^5	X^5					
INMARSAT (MDC)	X^2		X^2	X^2		X^2	X^2	X^2	X^2	X^2					
RESOURCES/POL'N/WEATH/COMM (MDC)	X		X	X		X	X	X	X	X					
EARTH OBS/COMMUN (MDC)	X		X	X		X	X	X	X	X					
INMETSAT (MDC)	X^3		X^3	X^3		X^3	X^3	X^3	X^3	X^3					
US/FOR. COMM (MDC)	X		X	X		X	X	X	X	X					
FOREIGN COMM (MDC)	X^2		X^2	X^2		X^2	X^2	X^2	X^2	X^2					
US COMM (MDC)	X^3		X^3	X^3		X^3	X^3	X^3	X^3	X^3					
RESOURCES/POL'N/WEATH/COMM (MDC)	X		X	X		X	X	X	X	X					
US COMM (MDC)	X		X	X		X	X	X	X	X					
US COMM (MDC)	X		X	X		X	X	X	X	X					
ORBIT TRANS VEH (T-10)	X^2			X^2	X^2	X^2	X^2	X^2	X^2	X^2					
OPTIONAL SERVICE MISSIONS												X^5	X^5		X^5
FOREIGN COMM (MDC)	X		X	X		X	X	X	X	X					
1991 MISSIONS															
FOR COMM/SBS (MDC)	X^5		X^5	X^5		X^5	X^5	X^5	X^5	X^5					
RESOURCES/POL'N/WEATH/COMM (MDC)	X		X	X		X	X	X	X	X					
MAP GRAVITY FIELD/COMM (MDC)	X		X	X		X	X	X	X	X					
FOR. COMM/EARTH OBS (MDC)	X		X	X		X	X	X	X	X					
INMETSAT (MDC)	X^4		X^4	X^4		X^4	X^4	X^4	X^4	X^4					
US/FOR. COMM (MDC)	X		X	X		X	X	X	X	X					
FOREIGN COMM (MDC)	X		X	X		X	X	X	X	X					
RESOURCES/POL'N/WEATH/COMM (MDC)	X^2		X^2	X^2		X^2	X^2	X^2	X^2	X^2					
ORBIT TRANS VEH (T-10)	X^2			X^2	X^2	X^2	X^2	X^2	X^2	X^2					
OPTIONAL SERVICE MISSIONS												X^4	X^4		X^4
FOREIGN COMM/EARTH OBS (MDC)	X^2		X^2	X^2		X^2	X^2	X^2	X^2	X^2					
ELECTRONIC MAIL (MDC)	X			X		X	X	X	X	X					

NOTE: EXPONENT INDICATES NUMBER OF USES

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B13 – INITIAL LAUNCH – EQUIPMENT UTILIZATION SUMMARY – PLANETARY/OTHER MISSIONS ('84, '85)
RMS PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT											OPTIONAL EQUIPMENT			
	RETENTION STRUCTURE	TILT TABLE	SPIN TABLE	RMS	PIDA	MFR/RMS	MMU/WRU		HPA	MTV	VSS	SUN SHIELD	ORBITAL STORAGE	ATTITUDW TRANSFER PACKAGE	LIGHT ENHANCE-MENT
1984 MISSIONS							WITH END-EFFECTOR	WITH STABILIZER							
PLANETARY															
GALILEO ORBITER (P-1)	X			X	X	X	X	X		X					
GALILEO PROBE (P-1)	X			X	X	X	X	X		X					
AMPTE-ALT MAG PART EXPT (S-6)	X			X	X	X	X	X		X					
OPTIONAL SERVICE MISSIONS												X	X	X	X
1985 MISSIONS															
PLANETARY															
HALLEY FLYBY (P-3, 5 YR)	X			X	X	X	X	X		X					
INT SOLAR POLAR MISS. (A-3, S-3, FAM)	X^2			X^2	X^2	X^2	X^2	X^2		X^2					
OPTIONAL SERVICE MISSIONS												X	X	X	X

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NOTE: EXPONENT INDICATES NUMBER OF USES

B14 – INITIAL LAUNCH – EQUIPMENT UTILIZATION SUMMARY – PLANETARY/OTHER MISSIONS ('86 TO '93)
HPA PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT											OPTIONAL EQUIPMENT			
	RETENTION STRUCTURE	TILT TABLE	SPIN TABLE	RMS	PIDA	MFR/RMS	MMU/WRU		HPA	MTV	VSS	SUN SHIELD	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCEMENT
1986 MISSIONS							WITH END EFFECTOR	WITH STABILIZER							
PLANETARY															
VENUS ORBIT IMG RAD (P-2)	X			X	X	X	X	X	X	X					
ORIGIN OF PLASMA	X^4			X^4	X^4	X^4	X^4	X^4	X^4	X^4					
COMET RENDEZ (P-3, 5 YR)	X			X	X	X	X	X	X	X					
OPTIONAL SERVICE MISSIONS												X	X		X
1987 MISSIONS															
PLANETARY															
PLASMA TURB EXPLOR	X			X	X	X	X	X	X	X					
1988 MISSIONS															
PLANETARY															
SOLAR PROBE (S-11)	X			X	X	X	X	X	X	X					
1989 MISSIONS															
PLANETARY															
ADV INTERPLAN EXPLORER (G)	X			X	X	X	X	X	X	X					
SATURN ORBIT (DUAL) (P-4)	X			X	X	X	X	X	X	X					
OPTIONAL SERVICE MISSIONS												X	X		X
1991 MISSIONS															
UNP PROG-URAN NEP PLUTO (P-6)	X			X	X	X	X	X	X	X					
1992 MISSIONS															
PLANETARY															
UNP PROG-URAN NEP PLUTO (P-6)	X			X	X	X	X	X	X	X					
1993 MISSIONS															
PLANETARY															
LUNAR POLAR ORBIT (P-8)	X			X	X	X	X	X	X	X					
NR EARTH ASTEROID SAMPLE (P-11)	X			X	X	X	X	X	X	X					
ASTEROID MULT RENDEZ (P-7)	X			X	X	X	X	X	X	X					
EXTRATERRESTRIAL MAT'L PROC (U-3)	X			X	X	X	X	X	X	X					
OPTIONAL SERVICE MISSIONS												X	X		X

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NOTE: EXPONENT INDICATES NUMBER OF USES

B15 – INITIAL LAUNCH – EQUIPMENT UTILIZATION SUMMARY – SORTIE MISSIONS ('83 TO '85)

RMS PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT											OPTIONAL EQUIPMENT			
	RETENTION STRUCTURE	TILT TABLE	SPIN TABLE	RMS	PIDA	MFR/RMS	MMU/WRU WITH END EFFECTOR	MMU/WRU WITH STABILIZER	HPA	MTV	VSS	SUN SHIELD	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCEMENT
1983 MISSIONS															
OSTA (SPACE & TERRESTRIAL APPLICATIONS)				X		X	X	X							
SPACELAB-1 (VERIF & MULTIDISCIPLINE)				X		X	X	X							
TETHERED SATELLITE SYSTEM (U-4)				X		X	X	X							
SPACELAB (SOLAR & ASTRO PHYSICS)				X		X	X	X							
MPS (MATERIAL PROCESSING) (U-1)				X		X	X	X							
1984 MISSIONS															
OSTA (SPACE & TERRESTRIAL APPLICATIONS)				X^2		X^2	X^2	X^2							
SPAS-01				X		X	X	X							
TETHERED SATELLITE SYSTEM (U-4)				X		X	X	X							
MPS (MATERIAL PROCESSING) (U-1)				X^2		X^2	X^2	X^2							
PEP-PWR EXT PKG				X^2		X^2	X^2	X^2							
SPACELAB-3 (LOW GRAVITY)				X		X	X	X							
SPACELAB (LIFE SCIENCES) (L-1)				X		X	X	X							
OSS (SPACE SCIENCES)				X		X	X	X							
SPACELAB (BMFT)				X		X	X	X							
SPACELAB (SOLAR TERR)				X		X	X	X							
1985 MISSIONS															
OSTA (SPACE & TERRESTRIAL APPLICATIONS)				X^2		X^2	X^2	X^2							
TETHERED SATELLITE SYSTEM (U-4)				X		X	X	X							
SPACELAB (SOLAR & ASTRO PHYSICS)				X		X	X	X							
MPS (MATERIAL PROCESSING) (U-1)				X		X	X	X							
PEP-PWR EXT PKG				X^4		X^4	X^4	X^4							
SPACELAB (LIFE SCIENCES) (L-1)				X		X	X	X							
OSS (SPACE SCIENCES)				X^2		X^2	X^2	X^2							
SPACELAB (BMFT)				X		X	X	X							
LARGE DEPLOY. ANTENNA (GAC)				X		X	X	X							
SPACELAB (EARTH OBS)				X		X	X	X							
SPACELAB (MATL PROC)				X		X	X	X							

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NOTE: EXPONENT INDICATES NUMBER OF USES

B16 – INITIAL LAUNCH – EQUIPMENT UTILIZATION SUMMARY – SORTIE MISSIONS ('86 TO '88)
RMS PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT											OPTIONAL EQUIPMENT			
	RETENTION STRUCTURE	TILT TABLE	SPIN TABLE	RMS	PIDA	MFR/RMS	MMU/WRU		HPA	MTV	VSS	SUN SHIELD	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCEMENT
1986 MISSIONS							WITH END EFFECTOR	WITH STABILIZER							
OSTA (SPACE & TERRESTRIAL APPLICATIONS)				X^2		X^2	X^2	X^2							
SPAS-01				X		X	X	X							
TETHERED SATELLITE SYSTEM (U-4)				X		X	X	X							
SPACELAB (SOLAR & ASTRO PHYSICS)				X^2		X^2	X^2	X^2							
MPS (MATERIAL PROCESSING) (U-1)				X		X	X	X							
PEP PWR EXT PKG				X^6		X^6	X^6	X^6							
SPACELAB (LIFE SCIENCES) (L-1)				X		X	X	X							
OSS (SPACE SCIENCES)				X^2		X^2	X^2	X^2							
SPACELAB (BMFT)				X		X	X	X							
SPACELAB (SOLAR TERR)				X		X	X	X							
SPACELAB (MATL PROC)				X		X	X	X							
SPACELAB-11 PLASMA				X		X	X	X							
SIRT-IR TELE FAC (A-6) (2 PALLET)				X		X	X	X							
1987 MISSIONS															
OSTA (SPACE & TERRESTRIAL APPLICATIONS)				X^2		X^2	X^2	X^2							
TETHERED SATELLITE SYSTEM (U-4)				X		X	X	X							
SPACELAB (SOLAR & ASTRO PHYSICS)				X		X	X	X							
MPS (MATERIAL PROCESSING) (U-1)				X		X	X	X							
PEP PWR EXT PKG				X^7		X^7	X^7	X^7							
OSS (SPACE SCIENCES)				X^2		X^2	X^2	X^2							
SPACELAB (BMFT)				X		X	X	X							
SPACELAB (EARTH OBS)				X		X	X	X							
SPACELAB (MATL PROC)				X		X	X	X							
STARLAB TELESCOPE (A-11, G) (2 PALLET)				X		X	X	X							
SOLAR SOFT X-RAYS (S-8) (1 PALLET)				X		X	X	X							
1988 MISSIONS															
OSTA (SPACE & TERRESTRIAL APPLICATIONS)				X^2		X^2	X^2	X^2							
SPAS-01				X		X	X	X							
SPACELAB (SOLAR & ASTRO PHYSICS)				X		X	X	X							
MPS (MATERIAL PROCESSING) (U-1)				X		X	X	X							
PEP-PWR EXT PKG				X^8		X^8	X^8	X^8							
SPACELAB (LIFE SCIENCES) (L-1)				X		X	X	X							
OSS (SPACE SCIENCES)				X^2		X^2	X^2	X^2							
SPACELAB (BMFT)				X		X	X	X							
SPACELAB (SOLAR TERR)				X		X	X	X							
SPACELAB (MATL PROC)				X		X	X	X							
SPACELAB-PIN HOLE (S-14) (1 PALLET)				X		X	X	X							
LIDAR (ET-47) (1 PALLET)				X		X	X	X							

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NOTE EXPONENT INDICATES NUMBER OF USES

B17 – INITIAL LAUNCH – EQUIPMENT UTILIZATION SUMMARY – SORTIE MISSIONS ('89 TO '91)
RMS PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT											OPTIONAL EQUIPMENT			
	RETENTION STRUCTURE	TILT TABLE	SPIN TABLE	RMS	PIDA	MFR/RMS	MMU/WRU WITH END EFFECTOR	MMU/WRU WITH STABILIZER	HPA	MTV	VSS	SUN SHIELD	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCEMENT
1989 MISSIONS															
OSTA (SPACE & TERRESTRIAL APPLICATIONS)				X^2		X^2	X^2	X^2							
SPACELAB (SOLAR & ASTRO PHYSICS)				X		X	X	X							
MPS (MATERIAL PROCESSING) (U-1)				X		X	X	X							
PEP-PWR EXT PKG				X^8		X^8	X^8	X^8							
SPACELAB (LIFE SCIENCES) (L-1)				X		X	X	X							
OSS (SPACE SCIENCES)				X^2		X^2	X^2	X^2							
SPACELAB (BMFT)				X		X	X	X							
SPACELAB (EARTH OBS)				X		X	X	X							
SPACELAB (MATL PROC)				X		X	X	X							
1990 MISSIONS															
OSTA (SPACE & TERRESTRIAL APPLICATIONS)				X^2		X^2	X^2	X^2							
SPAS-01				X		X	X	X							
SPACELAB (SOLAR & ASTRO PHYSICS)				X		X	X	X							
MPS (MATERIAL PROCESSING) (U-1)				X		X	X	X							
PEP-PWR EXT PKG				X^8		X^8	X^8	X^8							
OSS (SPACE SCIENCES)				X^2		X^2	X^2	X^2							
SPACELAB (BMFT)				X		X	X	X							
SPACELAB (SOLAR TERR)				X		X	X	X							
SPACELAB (MATL PROC)				X		X	X	X							
1991 MISSIONS															
OSTA (SPACE & TERRESTRIAL APPLICATIONS)				X^2		X^2	X^2	X^2							
SPACELAB (SOLAR & ASTRO PHYSICS)				X		X	X	X							
MPS (MATERIAL PROCESSING) (U-1)				X		X	X	X							
PEP-PWR EXT PKG				X^8		X^8	X^8	X^8							
SPACELAB (LIFE SCIENCES) (L-1)				X		X	X	X							
OSS (SPACE SCIENCES)				X^2		X^2	X^2	X^2							
SPACELAB (BMFT)				X		X	X	X							
SPACELAB (EARTH OBS)				X		X	X	X							
SPACELAB (MATL PROC)				X		X	X	X							

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NOTE: EXPONENT INDICATES NUMBER OF USES

B18 – INITIAL LAUNCH – EQUIPMENT UTILIZATION SUMMARY – SORTIE MISSIONS ('92, '93)
RMS PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT											OPTIONAL EQUIPMENT			
	RETENTION STRUCTURE	TILT TABLE	SPIN TABLE	RMS	PIDA	MFR/RMS	MMU/WRU		HPA	MTV	VSS	SUN SHIELD	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCEMENT
1992 MISSIONS							WITH END EFFECTOR	WITH STABILIZER							
OSTA (SPACE & TERRESTRIAL APPLICATIONS)				X^2		X^2	X^2	X^2							
SPAS-01				X		X	X	X							
SPACELAB (SOLAR & ASTRO PHYSICS)				X		X	X	X							
MPS (MATERIAL PROCESSING) (U-1)				X		X	X	X							
PEP-PWR EXT PKG				X^8		X^8	X^8	X^8							
SPACELAB (LIFE SCIENCES) (L-1)				X		X	X	X							
OSS (SPACE SCIENCES)				X^2		X^2	X^2	X^2							
SPACELAB (BMFT)				X		X	X	X							
SPACELAB (SOLAR TERR)				X		X	X	X							
SPACELAB (MATL PROC)				X		X	X	X							
1993 MISSIONS															
OSTA (SPACE & TERRESTRIAL APPLICATIONS)				X^2		X^2	X^2	X^2							
SPACELAB (SOLAR & ASTRO PHYSICS)				X		X	X	X							
MPS (MATERIAL PROCESSING) (U-1)				X		X	X	X							
PEP-PWR EXT PKG				X^8		X^8	X^8	X^8							
OSS (SPACE SCIENCES)				X^2		X^2	X^2	X^2							
SPACELAB (BMFT)				X		X	X	X							
SPACELAB (EARTH OBS)				X		X	X	X							
SPACELAB (MATL PEP-PO)				X		X	X	X							

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NOTE: EXPONENT INDICATES NUMBER OF USES

B19 – INITIAL LAUNCH – EQUIPMENT UTILIZATION SUMMARY – DoD MISSIONS ('83 TO '85)
RMS PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT											OPTIONAL EQUIPMENT			
	RETENTION STRUCTURE	TILT TABLE	SPIN TABLE	RMS	PIDA	MFR/RMS	MMU/WRU		HPA	MTV	VSS	SUN SHIELD	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCEMENT
							WITH END EFFECTOR	WITH STABILIZER							
1983 MISSIONS															
DoD 83-1				X		X	X	X							
DoD 83-2				X		X	X	X							
DoD 84-1				X		X	X	X							
P80-1-STP	X	X		X		X	X	X		X					
SPACE IR EXPERIMENT (SIRE)	X	X		X		X	X	X		X					
1984 MISSIONS															
DoD 84-2				X		X	X	X							
DoD 85-1				X		X	X	X							
DoD 85-2				X		X	X	X							
SPACE IR EXPERIMENT (SIRE)	X	X		X		X	X	X		X					
GLOBAL POSITIONING SAT.	X	X	X	X		X	X	X		X					
TRANSIT	X	X		X		X	X	X		X					
OPTIONAL SERVICE MISSIONS												X	X	X	X
1985 MISSIONS															
DoD 85-3				X		X	X	X							
DoD 85-4				X		X	X	X							
DoD 85-5				X		X	X	X							
DoD 85-6				X		X	X	X							
DoD 85-7				X		X	X	X							
DoD 85-8				X		X	X	X							
DoD 86-1				X		X	X	X							
GLOBAL POSITIONING SAT.	X^4	X^4	X^4	X^4		X^4	X^4	X^4		X^4					
TRANSIT	X	X		X		X	X	X		X					
DEFENSE SAT. COMM SYSTEM	X^2	X^2		X^2		X^2	X^2	X^2		X^2					
SPACE IR EXP	X	X		X		X	X	X		X					
OPTIONAL SERVICE MISSIONS												X^2	X^2	X^2	X^2

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NOTE. EXPONENT INDICATES NUMBER OF USES

B20 – INITIAL LAUNCH – EQUIPMENT UTILIZATION SUMMARY – DoD MISSIONS ('86, '87)
HPA PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT											OPTIONAL EQUIPMENT			
	RETENTION STRUCTURE	TILT TABLE	SPIN TABLE	RMS	PIDA	MFR/RMS	MMU/WRU		HPA	MTV	VSS	SUN SHIELD	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCEMENT
1986 MISSIONS							WITH END EFFECTOR	WITH STABILIZER							
DoD 86-2				X		X	X	X							
DoD 86-3				X		X	X	X							
DoD 86-6				X		X	X	X							
DoD 86-8				X		X	X	X							
DoD 86-10				X		X	X	X							
DoD 86-11				X		X	X	X							
GLOBAL POSITIONING SAT.	X^6		X^6	X^6		X^6	X^6	X^6	X^6	X^6					
TRANSIT	X			X		X	X	X	X	X					
DEFENSE SAT COMM SYSTEM (1)	X^2			X^2		X^2	X^2	X^2	X^2	X^2					
SPACE TEST PROGRAM (STP)	X			X		X	X	X	X	X					
TALON GOLD-STP	X			X		X	X	X	X						
OPTIONAL SERVICE MISSIONS												X^2	X^2		X^2
1987 MISSIONS															
GLOBAL POSITIONING SAT.	X^7		X^7	X^7		X^7	X^7	X^7	X^7	X^7					
TRANSIT	X			X		X	X	X	X	X					
DEFENSE SAT. COMM SYSTEM	X^2			X^2		X^2	X^2	X^2	X^2	X^2					
SPACE TEST PROGRAM (STP)	X			X		X	X	X	X	X					
DEFENSE MET. SAT. PGM (DMSP)	X			X		X	X	X	X						
OPTIONAL SERVICE MISSIONS												X^2	X^2		X^2

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NOTE: EXPONENT INDICATES NUMBER OF USES

B21 – INITIAL LAUNCH – EQUIPMENT UTILIZATION SUMMARY – DoD MISSIONS ('88)
HPA PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT											OPTIONAL EQUIPMENT			
1988 MISSIONS	RETENTION STRUCTURE	TILT TABLE	SPIN TABLE	RMS	PIDA	MFR/RMS	MMU/WRU WITH END EFFECTOR	MMU/WRU WITH STABILIZER	HPA	MTV	VSS	SUN SHIELD	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCEMENT
GLOBAL POSITIONING SAT.	X^7		X^7	X^7		X^7	X^7	X^7	X^7	X^7					
TRANSIT	X			X		X	X	X	X	X					
SPACE TEST PROGRAM (STP)	X			X		X	X	X	X	X					
DEFENSE MET. SAT. PGM (DMSP)	X			X		X	X	X	X						
MINI HALO-STP	X			X		X	X	X	X	X					
OPTIONAL SERVICE MISSIONS												X^2	X^2		X^2

NOTE: EXPONENT INDICATES NUMBER OF USES

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B22 – INITIAL LAUNCH – EQUIPMENT UTILIZATION SUMMARY – DoD MISSIONS ('89 TO '93)
HPA PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT											OPTIONAL EQUIPMENT			
	RETENTION STRUCTURE	TILT TABLE	SPIN TABLE	RMS	PIDA	MFR/RMS	MMU/WRU WITH END EFFECTOR	MMU/WRU WITH STABILIZER	HPA	MTV	VSS	SUN SHIELD	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCEMENT
1989 MISSIONS															
GLOBAL POSITIONING SAT	x^2		x^2	x^2		x^2	x^2	x^2	x^2	x^2					
TRANSIT	x			x		x	x	x	x	x					
DEFENSE SAT COMM SYSTEM	x^2			x^2		x^2	x^2	x^2	x^2	x^2					
SPACE TEST PROGRAM (STP)	x			x		x	x	x	x	x					
DEFENSE MET. SAT PGM (DMSP)	x			x		x	x	x	x						
OPTIONAL SERVICE MISSIONS												x^2	x^2		x^2
1990 MISSIONS															
GLOBAL POSITIONING SAT.	x^4		x^4	x^4		x^4	x^4	x^4	x^4	x^4					
TRANSIT	x			x		x	x	x	x	x					
SPACE TEST PROGRAM (STP)	x			x		x	x	x	x	x					
DEFENSE MET. SAT. PGM (DMSP)	x			x		x	x	x	x						
OPTIONAL SERVICE MISSIONS												x^2	x^2		x^2
1991 MISSIONS															
GLOBAL POSITIONING SAT.	x^2		x^2	x^2		x^2	x^2	x^2	x^2	x^2					
TRANSIT	x			x		x	x	x	x	x					
DEFENSE SAT. COMM SYSTEM	x^2			x^2		x^2	x^2	x^2	x^2	x^2					
SPACE TEST PROGRAM (STP)	x			x		x	x	x	x	x					
DEFENSE MET. SAT. PGM (DMSP)	x			x		x	x	x	x						
OPTIONAL SERVICE MISSIONS												x	x		x
1992 MISSIONS															
GLOBAL POSITIONING SAT.	x^4		x^4	x^4		x^4	x^4	x^4	x^4	x^4					
DEFENSE SAT. COMM SYSTEM	x^2			x^2		x^2	x^2	x^2	x^2	x^2					
SPACE TEST PROGRAM (STP)	x			x		x	x	x	x	x					
DEFENSE MET. SAT. PGM (DMSP)	x			x		x	x	x	x						
OPTIONAL SERVICE MISSIONS												x^2	x^2		x^2
1993 MISSIONS															
GLOBAL POSITIONING SAT.	x^2		x^2	x^2		x^2	x^2	x^2	x^2	x^2					
SPACE TEST PROGRAM (STP)	x			x		x	x	x	x	x					
DEFENSE MET. SAT. PGM (DMSP)	x			x		x	x	x	x						
OPTIONAL SERVICE MISSIONS												x	x		x

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NOTE. EXPONENT INDICATES NUMBER OF USES

B23 — REVISIT — EQUIPMENT UTILIZATION SUMMARY — DIRECT DELIVERY/SERVICING SATELLITE MISSIONS ('85 TO '89)
TILT TABLE PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT															OPTIONAL EQUIPMENT		
					OCP			MMU/WRU										
1985 MISSIONS	EQUIPMENT STOWAGE PROVISIONS	FLUID TRANSFER SYSTEM	TILT TABLE	RMS	WK PLAT FOR TILT TABLE	OCP/RMS	POM	WITH END EFFECTOR	WITH STABILIZER	WITH PAY-LOAD HDLG	HPA	NONCONT ACS	MTV POM	MTV	VSS	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCEMENT
SPACE TELESCOPE (A-3)	X	X	X	X	X	X		X	X^2	X		X	X	X				
1986 MISSIONS	HPA PRIME USAGE																	
SPACE TELESCOPE (A-3)	X	X		X		X		X	X	X	X	X	X	X				
GRO-GAMMA RAY OBSER (A-7)	X	X		X		X		X	X	X	X		X	X				
OPTIONAL SERVICE MISSIONS																X		X
1987 MISSIONS																		
SPACE TELESCOPE (A-3)	X	X		X		X		X	X	X	X	X	X	X				
LDEF (01-10)	X	X		X		X	X	X	X	X	X	X		X				
SASP-SCI & APP SP PLAT (U-7 & L-2)	X	X		X		X		X	X	X	X			X				
25kW PWR MOD (U-8)	X	X		X		X		X	X	X	X			X				
OPTIONAL SERVICE MISSIONS																X		X
1988 MISSIONS																		
SPACE TELESCOPE (A-3)	X	X		X		X		X	X	X	X	X	X	X				
SASP-SCI & APP SP PLAT (U-7 & L-2)	X	X		X		X		X	X	X	X			X				
25kW PWR MOD. (U 8)	X	X		X		X		X	X	X	X			X				
AXAF ADV X-RAY ASTRO (A-9)	X	X		X		X		X	X	X	X	X	X	X				
CRO-COSMIC RAY OBSER (A-13)	X	X		X		X		X	X	X	X		X	X				
GRAVITY PROBE B (A-8)	X	X		X		X		X	X	X	X		X	X				
COASTAL SAT (NAS)	X	X		X		X	X	X	X	X	X			X				
OPTIONAL SERVICE MISSIONS																X		X
1989 MISSIONS																		
SASP-SCI & APP SP PLAT (U-7 & L-2)	X^2	X^2		X^2		X^2		X^2	X^2	X^2	X^2			X^2				
25kW PWR MOD (U-8)	X^2	X^2		X^2		X^2		X^2	X^2	X^2	X^2			X^2				
MAG FIELD SURV B (R-7)	X	X		X		X	X	X	X	X	X			X				
AXAF-ADV X-RAY ASTRO (A-9)	X	X		X		X		X	X	X	X	X	X	X				
CRO-COSMIC RAY OBSER (A-13)	X	X		X		X		X	X	X	X		X	X				
GRAVITY PROBE B (A-8)	X	X		X		X		X	X	X	X		X	X				
COASTAL SAT. (NAS)	X	X		X		X	X	X	X	X	X			X				
OPTIONAL SERVICE MISSIONS																X^2		X^2

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1472-525(T)

NOTE: EXPONENT INDICATES NUMBER OF USES

B24 – REVISIT – EQUIPMENT UTILIZATION SUMMARY – DIRECT DELIVERY/SERVICING SATELLITE MISSIONS ('90 TO '92)
HPA PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT															OPTIONAL EQUIPMENT		
	EQUIPMENT STOWAGE PROVISIONS	FLUID TRANSFER SYSTEM	TILT TABLE	RMS	OCP		MMU/WRU				HPA	NONCONT ACS	MTV POM	MTV	VSS	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCEMENT
					WK PLAT FOR TILT TABLE	OCP/RMS	POM	WITH END EFFECTOR	WITH STABILIZER	WITH PAY-LOAD HDLG								
1990 MISSIONS																		
LDEF (01-10)	X	X		X		X	X	X	X	X	X	X		X				
SASP-SCI & APP SP PLAT (U-7 & L-2)	X^2	X^2		X^2		X^2		X^2	X^2	X^2	X^2			X^2				
25kW PWR MOD (U-8)	X^2	X^2		X^2		X^2		X^2	X^2	X^2	X^2			X^2				
MAG FIELD SURV B (R-7)	X	X		X		X	X	X	X	X	X			X				
COASTAL SAT. (NAS)	X	X		X		X	X	X	X	X	X			X				
OCEAN RESEARCH SAR (E-11)	X	X		X		X	X	X	X	X	X			X				
HVY NUCLEI EXPL (GSF)	X	X		X		X	X	X	X	X	X			X				
OPTIONAL SERVICE MISSIONS																X^2		X^2
1991 MISSIONS																		
SPACE TELESCOPE (A-3)	X	X		X		X		X	X	X	X	X	X	X				
LDEF (01-10)	X	X		X		X	X	X	X	X	X	X		X				
SASP-SCI & APP SP PLAT (U-7 & L-2)	X^2	X^2		X^2		X^2		X^2	X^2	X^2	X^2			X^2				
25kW PWR MOD. (U-8)	X	X		X		X		X	X	X	X			X				
COASTAL SAT. (NAS)	X	X		X		X	X	X	X	X	X			X				
OCEAN RESEARCH SAR (E-11)	X	X		X		X	X	X	X	X	X			X				
HVY NUCLEI EXPL (GSF)	X	X		X		X	X	X	X	X	X			X				
LG SOLAR OBSERV (LEP)	X	X		X		X		X	X	X	X	X	X	X				
OPTIONAL SERVICE MISSIONS																X^2		X^2
1992 MISSIONS																		
SPACE TELESCOPE (A-3)	X	X		X		X		X	X	X	X	X	X	X				
SASP-SCI & APP SP PLAT (U-7 & L-2)	X^2	X^2		X^2		X^2		X^2	X^2	X^2	X^2			X^2				
25kW PWR MOD. (U-8)	X^2	X^2		X^2		X^2		X^2	X^2	X^2	X^2			X^2				
AXAF-ADV X-RAY ASTRO (A-9)	X	X		X		X		X	X	X	X	X	X	X				
CRO-COSMIC RAY OBSER (A-13)	X	X		X		X		X	X	X	X		X	X				
OCEAN RESEARCH SAR (E-11)	X	X		X		X	X	X	X	X	X			X				
HVY NUCLEI EXPL (GSF)	X	X		X		X	X	X	X	X	X			X				
LG SOLAR OBSERV (LEP)	X	X		X		X		X	X	X	X	X	X	X				
SOLAR TERR OBS (S-12)	X	X		X		X		X	X	X	X	X	X	X				
OPTIONAL SERVICE MISSIONS																X^2		X^2

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1472-526(T)

NOTE: EXPONENT INDICATES NUMBER OF USES

B25 – REVISIT – EQUIPMENT UTILIZATION SUMMARY – DIRECT DELIVERY/SERVICING SATELLITE MISSIONS ('93)
HPA PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT															OPTIONAL EQUIPMENT		
					OCP		MMU/WRU											
1993 MISSIONS	EQUIPMENT STOWAGE PROVISIONS	FLUID TRANSFER SYSTEM	TILT TABLE	RMS	WK PLAT FOR TILT TABLE	OCP/RMS	POM	WITH END EFFECTOR	WITH STABILIZER	WITH PAY-LOAD HDLG	HPA	NONCONT ACS	MTV POM	MTV	VSS	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCEMENT
SPACE TELESCOPE (A-3)	X	X		X		X		X	X	X	X	X	X	X				
SASP-SCI & APP SP PLAT (U-7 & L-2)	X^2	X^2		X^2		X^2		X^2	X^2	X^2	X^2			X^2				
25kW PWR MOD. (U-8)	X	X		X		X		X	X	X	X			X				
AXAF-ADV X-RAY ASTRO (A-9)	X	X		X		X		X	X	X	X	X	X	X				
CRO-COSMIC RAY OBSER (A-13)	X	X		X		X		X	X	X	X		X	X				
OCEAN RESEARCH SAR (E-11)	X	X		X		X	X	X	X	X	X			X				
LG SOLAR OBSERV (LEP)	X	X		X		X		X	X	X	X	X	X	X				
SOLAR TERR OBS (S-12)	X	X		X		X		X	X	X	X	X	X	X				
ADVANCED RELATIVITY (LEP)	X^2	X^2		X^2		X^2		X^2	X^2	X^2	X^2		X^2	X				
AMBIENT DEPLOY IR TELE (A-17)	X	X		X		X		X	X	X	X	X	X	X				
OPTIONAL SERVICE MISSIONS																X^2		X^2

R81 1108-1340
1472 527(T)

NOTE: EXPONENT INDICATES NUMBER OF USES

B26 – REVISIT – EQUIPMENT UTILIZATION SUMMARY – LEO/PROPULSION SATELLITE MISSIONS ('86 TO '89)
HPA PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT															OPTIONAL EQUIPMENT		
					OCP		MMU/WRU											
1986 MISSIONS	EQUIPMENT STOWAGE PROVISIONS	FLUID TRANSFER SYSTEM	TILT TABLE	RMS	WK PLAT FOR TILT TABLE	OCP/RMS	POM	WITH END EFFECTOR	WITH STABILIZER	WITH PAY-LOAD HDLG	HPA	NONCONT ACS	MTV POM	MTV	VSS	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCEMENT
LANDSAT D '' (5 YR)	X	X		X		X	X	X	X	X	X	X		X				
1987 MISSIONS																		
LANDSAT D ''' (5 YR)	X	X		X		X	X	X	X	X	X	X		X				
ORBITER CAMERA FR FLYER (MML)	X^3	X^3		X^3		X^3		X^3	X^3	X^3	X^3		X^3	X^3				
NOSS-NAT OCEAN SAT. (E-6)	X	X		X		X		X	X	X	X		X	X				
X-RAY TIME EXPL (A-10, GSF)	X	X		X		X		X	X	X	X	X	X	X				
ICEX-ICE & CLIM EXP (5 YR)	X	X		X		X		X	X	X	X		X	X				
OPTIONAL SERVICE MISSIONS																X^2		X^2
1988 MISSIONS																		
NOAA (E-5)	X	X		X		X		X	X	X	X	X	X	X				
REGION H_2O QUAL MON (LEP)	X	X		X		X		X	X	X	X		X	X				
ORBITER CAMERA FR FLYER (MML)	X	X		X		X		X	X	X	X		X	X				
UARS-UPPER ATMOS RES (E-7)	X	X		X		X		X	X	X	X		X	X				
NOSS NAT OCEAN SAT (E-6)	X	X		X		X		X	X	X	X			X	X			
HI ENERGY EXPL (NAS)	X	X		X		X		X	X	X	X		X	X				
ASTROPHYSICS EXPL (GSF)	X	X		X		X		X	X	X	X		X	X				
OP LAND OBSER SYS (LEP (R-5)	X	X		X		X		X	X	X	X		X	X				
OPTIONAL SERVICE MISSIONS																X^2		X^2
1989 MISSIONS																		
ERBS EARTH RAD BUDGET SAT (E-4)	X	X		X		X		X	X	X	X	X	X	X				
NOAA (E-5)	X	X		X		X		X	X	X	X			X	X			
ORBITER CAMERA FR FLYER (MML)	X^2	X^2		X^2		X^2		X^2	X^2	X^2	X^2			X^2	X^2			
UARS-UPPER ATMOS RES (E-7)	X^2	X^2		X^2		X^2		X^2	X^2	X^2	X^2		X	X^2	X			
OP LAND OBSER SYS (LEP) (R-5)	X	X		X		X		X	X	X	X			X	X			
ALL WEATHER MICROWAVE (LEP)	X	X		X		X		X	X	X	X			X	X			
EARTH SURVEY (LEP)	X	X		X		X		X	X	X	X	X		X	X			
LAMAR LG AREA MOD ARRAY (A-14, GSF)	X	X		X		X		X	X	X	X	X		X	X			
OPTIONAL SERVICE MISSIONS																X^2		X^2

NOTE EXPONENT INDICATES NUMBER OF USES

R81-1108-135D-138D
1472-528(T)

B27 – REVISIT – EQUIPMENT UTILIZATION SUMMARY – LEO/PROPULSION SATELLITE MISSIONS ('90 TO '92)
HPA PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT															OPTIONAL EQUIPMENT		
	EQUIPMENT STOWAGE PROVISIONS	FLUID TRANSFER SYSTEM	TILT TABLE	RMS	OCP		MMU/WRU				HPA	NONCONT ACS	MTV POM	MTV	VSS	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCEMENT
1990 MISSIONS					WK PLAT FOR TILT TABLE	OCP/RMS	POM	WITH END EFFECTOR	WITH STABILIZER	WITH PAY-LOAD HDLG								
UARS-UPPER ATMOS RES (E-7)	x^2	x^2		x^2		x^2		x^2	x^2	x^2	x^2		X	x^2	X			
NOSS-NAT OCEAN SAT (E-6)	X	X		X		X		X	X	X	X			X	X			
X-RAY TIME EXPL (A-10, GSF)	X	X		X		X		X	X	X	X	X		X	X			
ICEX-ICE & CLIM EXP (5 YR)	X	X		X		X		X	X	X	X			X	X			
OP LAND OBSER SYS (LEP) (R-5)	X	X		X		X		X	X	X	X			X	X			
ADV GEOLOGY SAT (LEP)	X	X		X		X		X	X	X	X			X	X			
GLOBAL REGIONAL ATHMOS MONITOR (LEP)	X	X		X		X		X	X	X	X			X	X			
LAMAR-LG AREA MOD. ARRAY (A-14, GSF)	X	X		X		X		X	X	X	X	X		X	X			
PRIV EARTH RES (LEP)	X	X		X		X		X	X	X	X	X		X	X			
ATMAS-ADV THERM MAP (R-6)	X	X		X		X		X	X	X	X			X	X			
VLBI-V, LG BASE INT (A-15)	X	X		X		X		X	X	X	X			X	X			
OPTIONAL SERVICE MISSIONS																x^2		x^2
1991 MISSIONS																		
UARS-UPPER ATMOS RES (E-7)	X	X		X		X		X	X	X	X			X	X			
NOSS-NAT OCEAN SAT. (E-6)	X	X		X		X		X	X	X	X			X	X			
ICEX-ICE & CLIM EXP (5 YR)	X	X		X		X		X	X	X	X			X	X			
EARTH SURVEY (LEP)	x^2	x^2		x^2		x^2		x^2	x^2	x^2	x^2	x^2		x^2	x^2			
LAMAR LG AREA MOD. ARRAY (A 14, GSF)	X	X		X		X		X	X	X	X	X		X	X			
VLBI-V, LG BASE INT (A 15)	X	X		X		X		X	X	X	X			X	X			
ENVIRON MONITOR (LEP)	X	X		X		X		X	X	X	X			X	X			
OP METEOROLOGY (E-10)	X	X		X		X		X	X	X	X			X	X			
ASTRONOMY (MDC)	X	X		X		X		X	X	X	X	X		X	X			
X-RAY OBSERVATORY (GSF)	X	X		X		X		X	X	X	X	X		X	X			
OPTIONAL SERVICE MISSIONS																x^2		x^2
1992 MISSIONS																		
UARS-UPPER ATMOS RES (E-7)	x^2	x^2		x^2		x^2		x^2	x^2	x^2	x^2		X	x^2	X			
OP LAND OBSER SYS (LEP) (R-5)	X	X		X		X		X	X	X	X			X	X			
LAMAR LG AREA MOD ARRAY (A-14, GSF)	X	X		X		X		X	X	X	X	X		X	X			
ATMAS-ADV THERM MAP (R-6)	x^2	x^2		x^2		x^2		x^2	x^2	x^2	x^2			x^2	x^2			
VLBI-V, LG BASE INT (A-15)	X	X		X		X		X	X	X	X			X	X			
OPTIONAL SERVICE MISSIONS																x^2		x^2

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NOTE: EXPONENT INDICATES NUMBER OF USES

B28 – REVISIT – EQUIPMENT UTILIZATION SUMMARY – LEO/PROPULSION SATELLITE MISSIONS ('93)
HPA PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT															OPTIONAL EQUIPMENT		
					OCP		MMU/WRU											
1993 MISSIONS	EQUIPMENT STOWAGE PROVISIONS	FLUID TRANSFER SYSTEM	TILT TABLE	RMS	WK PLAT FOR TILT TABLE	OCP/RMS	POM	WITH END EFFECTOR	WITH STABILIZER	WITH PAY-LOAD HDLG	HPA	NONCONT ACS	MTV POM	MTV	VSS	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCEMENT
ERBS-EARTH RAD BUDGET SAT. (E-4)	X	X		X		X		X	X	X	X	X	X	X				
UARS-UPPER ATMOS RES (E-7)	X^2	X^2		X^2		X^2		X^2	X^2	X^2	X^2		X	X^2	X			
OP LAND OBSER SYS (LEP) (R-6)	X	X		X		X		X	X	X	X			X	X			
SCADM-SOLAR CYCLES & DYNAMICS MISS	X	X		X		X		X	X	X	X			X	X			
EARTH SURVEY (LEP)	X^3	X^3		X^3		X^3		X^3	X^3	X^3	X^3	X^3		X^3	X^3			
VLBI-V, LG BASE INT (A-15)	X	X		X		X		X	X	X	X			X	X			
ENVIRON MONITOR (LEP)	X^2	X^2		X^2		X^2		X^2	X^2	X^2	X^2			X^2	X^2			
ASTRONOMY (MDC)	X	X		X		X		X	X	X	X	X		X	X			
OPTIONAL SERVICE MISSIONS																X^2		X^2

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1472 530(T)

NOTE EXPONENT INDICATES NUMBER OF USES

B29 — EARTH RETURN — EQUIPMENT UTILIZATION SUMMARY — DIRECT DELIVERY/SERVICING SATELLITE MISSIONS ('84, '85)
RMS PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT																	
						OCP			MMU/WRU							VSS		
1984 MISSIONS	RETENTION STRUCT	SPEC RETEN-TION STRUCT	EQUIP. STOW. PROV	TILT TABLE	PIDA	TILT TABLE WORK PLAT	RMS	MFR RMS	W/ END EFFECTOR	WITH STABILIZER	POM	MTV POM	HPA	NONCONTAM ACS	MTV	W/ DOCKING RENDEZ	W/ END EFFECTOR	WITH DEBRIS CAPTURE
SPAS-01 STS PALLET SAT.	X							X	X	X^2					X			
1985 MISSIONS																		
SPAS-01 STS PALLET SAT.	X							X	X	X^2					X			
LDEF (01-10)	X							X	X	X^2	X			X	X			

NOTE: EXPONENT INDICATES NUMBER OF USES

R81-1108-116D-117D
1472-531(T)

830 – EARTH RETURN – EQUIPMENT UTILIZATION SUMMARY – DIRECT DELIVERY/SERVICING SATELLITE MISSIONS ('86 TO '93)

RMS/HPA PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT																	
						OCP			MMU/WRU							VSS		
1986 MISSIONS	RETENTION STRUCT	SPEC RETENTION STRUCT	EQUIP. STOW. PROV	TILT TABLE	PIDA	TILT TABLE WORK PLAT	RMS	MFR RMS	W/ END EFFECTOR	WITH STABILIZER	POM	MTV POM	HPA	NONCONTAM ACS	MTV	W/ DOCKING RENDEZ	W/ END EFFECTOR	WITH DEBRIS CAPTURE
SUBSAT FACILITY (S-9)	X							X	X	X^2			X		X			
1987 MISSIONS																		
SPAS-01 STS PALLET SAT.	X							X	X	X^2			X		X			
GRO-GAMMA RAY OBSERV (A-7)	X				X			X	X	X^2		X	X		X			
SUBSAT FACILITY (S-9)	X							X	X	X^2			X		X			
1988 MISSIONS																		
LDEF (01-10)	X							X	X	X^2	X		X	X	X			
SUBSAT FACILITY (S-9)	X							X	X	X^2			X		X			
1989 MISSIONS																		
SPAS-01 STS PALLET SAT.	X							X	X	X^2			X		X			
SPACE TELESCOPE (A-3)	X			X		X		X	X	X		X		X	X			
SUBSAT FACILITY (S-9)	X							X	X	X^2			X		X			
1990 MISSIONS																		
SUBSAT FACILITY (S-9)	X							X	X	X^2			X		X			
AXAF-ADV X-RAY ASTRO (A-6)	X							X	X	X^2		X	X	X	X			
CRO-COSMIC RAY OBSER (A-13)	X				X			X	X	X		X	X		X			
GRAVITY PROBE B (A-8)	X							X	X	X^2		X	X		X			
1991 MISSIONS																		
SPAS-01 STS PALLET SAT.	X							X	X	X^2			X		X			
25kW PWR MOD. (U-8)	X				X			X	X	X			X		X			
MAG FIELD SURV B (R-7)	X							X	X	X^2	X		X		X			
SUBSAT FACILITY (S 9)	X							X	X	X^2			X		X			
1992 MISSIONS																		
LDEF (01-10)	X							X	X	X^2	X		X	X	X			
COASTAL SAT. (NAS)	X							X	X	X^2	X		X	X	X			
1993 MISSIONS																		
SPAS 01 STS PALLET SAT.	X							X	X	X^2			X		X			
25kW PWR MOD. (U-8)	X				X			X	X	X			X		X			
HVY NUCLEI EXPL (GSF)	X							X	X	X^2	X		X		X			

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1472-532(T)

NOTE: EXPONENT INDICATES NUMBER OF USES

B31 – EARTH RETURN – EQUIPMENT UTILIZATION SUMMARY – LEO/PROPULSION SATELLITE MISSIONS ('84 TO '87)
RMS/TILT TABLE PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT																	
	RETENTION STRUCT	SPEC RETEN-TION STRUCT	EQUIP. STOW. PROV	TILT TABLE	PIDA	OCP		MFR RMS	MMU/WRU			MTV POM	HPA	NONCONTAM ACS	MTV	VSS		
1984 MISSIONS						TILT TABLE WORK PLAT	RMS		W/ END EFFECTOR	WITH STABILIZER	POM					W/ DOCKING RENDEZ	W/ END EFFECTOR	WITH DEBRIS CAPTURE
CHEM REL MODULE (S-5)	X							X	X	X^2	X				X			
SOLAR MAX-SMM	X			X		X		X	X	X	X				X			
1986 MISSIONS	RMS/HPA & RMS/TILT TABLE PRIME USAGE																	
LANDSAT D (R-2)	X			X		X		X	X	X	X			X	X			
CHEM REL MODULE (S-5)	X							X	X	X^2	X		X		X			
ERBS EARTH RAD BUDGET SAT. (E-5)	X			X		X		X	X	X	X			X	X			
NOAA (E-5)	X			X		X		X	X	X		X		X	X			
1987 MISSIONS																		
COBE-COSMIC BKGND EXPL (GSF)	X			X		X		X	X	X					X			
EUVE-EXTREME UV EXPLORER (A-5)	X							X	X	X^2		X	X	X	X			
ORBITER CAMERA FR FLYER (MML)	X							X	X	X^2		X	X		X			
MAGSAT B (R-1)	X							X	X	X^2		X	X		X			

R81-1105-107D-109D
1472-533(T)

NOTE: EXPONENT INDICATES NUMBER OF USES

B32 – EARTH RETURN – EQUIPMENT UTILIZATION SUMMARY – LEO/PROPULSION SATELLITE MISSIONS ('88 TO '91)
RMS/HPA PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT																	
	RETENTION STRUCT	SPEC RETEN-TION STRUCT	EQUIP. STOW. PROV	TILT TABLE	PIDA	OCP		MFR	MMU/WRU		POM	MTV POM	HPA	NONCONTAM ACS	MTV	VSS		
						TILT TABLE WORK PLAT	RMS		W/ END EFFECTOR	WITH STABILIZER						W/ DOCKING RENDEZ	W/ END EFFECTOR	WITH DEBRIS CAPTURE
1988 MISSIONS																		
LANDSAT D'' (5 YR)	X			X		X		X	X	X	X			X	X			
NOSS-NAT OCEAN SAT. (E-6)	X							X	X	X^2		X	X		X			
X-RAY TIME EXPL (A-10, GSF)	X							X	X	X^2		X	X	X	X			
ICEX-ICE / CLIM EXP (5 YR)	X							X	X	X^2		X	X		X			
1989 MISSIONS																		
LANDSAT D''' (5 YR)	X			X		X		X	X	X	X			X	X			
ORBITER CAMERA FR FLYER (MML)	X							X	X	X^2		X	X		X			
NOSS-NAT OCEAN SAT. (E-6)	X							X	X	X^2			X		X	X		
OP LAND OBSER SYS (LEP) (R-5)	X							X	X	X^2		X	X		X			
1990 MISSIONS																		
NOAA (E-5)	X			X		X		X	X	X		X		X	X			
REGION H20 QUAL MON (LEP)	X							X	X	X^2		X	X		X			
HI ENERGY EXPL (NAS)	X							X	X	X^2		X	X		X			
ASTROPHYSICS EXPL (GSF)	X							X	X	X^2		X	X		X			
OP LAND OBSER SYS (LEP) (R-5)	X							X	X	X^2			X		X	X		
TOPEX-TOPOG EXP OCEAN CIRCULAT	X							X	X	X^2			X		X	X		
SCADM-SOLAR CYCLES & DYNAMICS	X							X	X	X^2			X		X	X		
1991 MISSIONS																		
ERBS EARTH RAD BUDGET SAT. (E-4)	X							X	X	X^2		X	X	X	X	X		
NOAA (E-5)	X							X	X	X^2			X	X	X	X		
X-RAY TIME EXPL (A-10, GSF)	X							X	X	X^2	X		X	X	X	X		
OP LAND OBSER SYS (LEP) (R-5)	X							X	X	X^2			X		X	X		
ALL WEATHER MICROWAVE (LEP)	X							X	X	X^2			X		X	X		
GAMMA-RAY TRANSIENT EXPL (GSF)	X							X	X	X^2			X	X	X	X		
UV PHOTOMET/POLARIMET EXPL (GSF)	X							X	X	X^2			X	X	X	X		

R81-1108-110D-113D
1472-534(T)

NOTE: EXPONENT INDICATES NUMBER OF USES

B33 – EARTH RETURN – EQUIPMENT UTILIZATION SUMMARY – LEO/PROPULSION SATELLITE MISSIONS ('92, '93)
RMS/HPA PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT																	
	RETENTION STRUCT	SPEC RETENTION STRUCT	EQUIP. STOW. PROV	TILT TABLE	PIDA	DCP			MMU/WRU							VSS		
1992 MISSIONS						TILT TABLE WORK PLAT	RMS	MFR RMS	W/ END EFFECTOR	WITH STABILIZER	POM	MTV POM	HPA	NONCONTAM ACS	MTV	W/ DOCKING RENDEZ	W/ END EFFECTOR	WITH DEBRIS CAPTURE
NOSS NAT OCEAN SAT. (E-6)	X							X	X	X^2			X		X	X		
ICEX-ICE & CLIM EXP (5 YR)	X							X	X	X^2			X		X	X		
ADV GEOLOGY SAT. (LEP)	X							X	X	X^2			X		X	X		
GLOBAL REGIONAL ATHMOS MONITOR	X							X	X	X^2			X		X	X		
PRIV EARTH RES (LEP)	X							X	X	X^2			X	X	X	X		
SOFT X-RAY SURVEY (GSF)	X							X	X	X^2			X	X	X	X		
X-RAY SPECTROSCOPY (GSF)	X							X	X	X^2			X		X	X		
1993 MISSIONS																		
NOSS-NAT OCEAN SAT (E-6)	X							X	X	X^2			X		X	X		
LAMAR LG AREA MOD ARRAY (A-14)	X							X	X	X^2			X		X	X		
OP METEROLOGY (E-10)	X							X	X	X^2			X		X	X		
MOLECALAR LINE SURVEY	X							X	X	X^2			X		X	X		

R81-1108-114-115D
1472-535(T)

NOTE EXPONENT INDICATES NUMBER OF USES

Appendix C

SSS Equipment Utilization

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Satellite Services System

C1 – SATELLITE SERVICES SYSTEM – MFR UTILIZATION

MISSION CATEGORY	FREQUENCY OF USE/YEAR										
	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92	'93
A. INITIAL LAUNCH											
(1) DIRECT DEL /SERV	1	2	2	6	10	7	7	6	9	5	7
(2) LEO/PROP. SAT.	2	3	5	12	9	10	11	8	5	7	4
(3) DoD	5	6	15	17	12	11	7	7	7	8	4
(4) PLANETARY	—	3	3	6	1	1	2	—	1	1	4
(5) GEO SAT.	8	15	13	15	17	22	24	26	21	21	31
(6) SORTIE	5	13	16	21	19	21	18	18	18	19	17
B. REVISIT											
(1) DIRECT DEL /SERV	—	—	—	—	—	—	—	—	—	—	—
(2) LEO/PROP. SAT.	—	—	—	—	—	—	—	—	—	—	—
C. EARTH RETURN											
(1) DIRECT DEL /SERV	—	1	2	1	3	2	3	4	4	2	3
(2) LEO/PROP. SAT.	—	2	—	4	4	4	4	7	7	7	4
TOTAL USES	21	45	56	82	75	78	76	76	72	70	74
NO. UNITS REQD	2	4	5	6	—	—	—		—	—	—
REQD DELIVERY	2	2	1	1	—	—	Σ THRU '90 = 509			—	—

R81-1108-028D
1472-536(T)

C2 — SATELLITE SERVICES SYSTEM — OCP UTILIZATION

MISSION CATEGORY	FREQUENCY OF USE/YEAR										
	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92	'93
A. INITIAL LAUNCH											
(1) DIRECT DEL /SERV											
(2) LEO/PROP. SAT.											
(3) DoD						← NONE →					
(4) PLANETARY											
(5) GEO SAT.											
(6) SORTIE											
B. REVISIT											
(1) DIRECT DEL SERV	—	—	1	2	4	7	9	9	9	11	12
(2) LEO/PROP. SAT.	—	—	—	1	7	8	10	12	11	7	12
C. EARTH RETURN											
(1) DIRECT DEL /SERV	—	—	—	—	—	—	—	—	—	—	—
(2) LEO/PROP. SAT.	—	1	—	3	1	1	1	1	—	—	—
TOTAL USES	—	1	1	6	12	16	20	22	20	18	24
NO. UNITS REQD	—	1	2	3	4	—	—		—	—	—
REQD DELIVERY	—	1	1	1	1	—		Σ THRU '90 = 78		—	—

R81-1108-041D
1472-537(T)

C3 – SATELLITE SERVICES SYSTEM – OCP TILT TABLE WORK PLATFORM UTILIZATION

MISSION CATEGORY	FREQUENCY OF USE/YEAR										
	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92	'93
A. INITIAL LAUNCH											
(1) DIRECT DEL /SERV											
(2) LEO/PROP. SAT.											
(3) DoD											
(4) PLANETARY						NONE					
(5) GEO SAT.											
(6) SORTIE											
B. REVISIT											
(1) DIRECT DEL /SERV	–	–	1	–	–	–	–	–	–	–	–
(2) LEO/PROP. SAT.	–	–	–	–	–	–	–	–	–	–	–
C. EARTH RETURN											
(1) DIRECT DEL/SERV	–	–	–	–	–	–	–	–	–	–	–
(2) LEO/PROP. SAT.	–	1	–	3	1	1	1	1	–	–	–
TOTAL USES	–	1	1	3	1	1	1	1	–	–	–
NO. UNITS REQD	–	1	–	–	–	–	–		–	–	–
REQD DELIVERY	–	1	–	–	–	–	Σ THRU '90 = 9		–	–	–

R81-1108-042D
1472-538(T)

C4 — SATELLITE SERVICES SYSTEM — HPA UTILIZATION

MISSION CATEGORY	FREQUENCY OF USE/YEAR										
	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92	'93
A. INITIAL LAUNCH											
(1) DIRECT DEL /SERV	—	—	—	6	10	7	7	6	9	5	7
(2) LEO/PROP. SAT.	—	—	—	12	9	10	11	8	5	7	4
(3) DoD	—	—	—	11	12	11	7	7	7	8	4
(4) PLANETARY	—	—	—	6	1	1	2	—	1	1	4
(5) GEO SAT.	—	—	—	15	17	22	24	26	21	21	31
(6) SORTIE	—	—	—	—	—	—	—	—	—	—	—
B. REVISIT											
(1) DIRECT DEL /SERV	—	—	—	2	4	7	9	9	9	11	12
(2) LEO/PROP. SAT.	—	—	—	1	7	8	10	12	11	7	12
C. EARTH RETURN											
(1) DIRECT DEL/SERV	—	—	—	1	3	2	2	4	4	2	3
(2) LEO/PROP. SAT.	—	—	—	1	3	3	3	6	7	7	4
TOTAL USES	—	—	—	55	66	71	75	78	74	69	81
NO. UNITS REQD	—	—	—	3	4	5	—	—		—	—
REQD DELIVERY	—	—	2	1	1	1	—	Σ THRU '90 = 345		—	—

R81-1108-026D
1472-539(T)

C5 — SATELLITE SERVICES SYSTEM — PIDA UTILIZATION.

MISSION CATEGORY	FREQUENCY OF USE/YEAR										
	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92	'93
A. INITIAL LAUNCH											
(1) DIRECT DEL /SERV	—	—	—	1	3	3	2	3	2	3	4
(2) LEO/PROP. SAT.	—	—	—	—	—	—	—	—	—	—	—
(3) DoD	—	—	—	—	—	—	—	—	—	—	—
(4) PLANETARY	—	3	3	6	1	1	2	—	1	1	4
(5) GEO SAT.	—	—	—	—	1	1	2	2	2	6	9
(6) SORTIE	—	—	—	—	—	—	—	—	—	—	—
B. REVISIT											
(1) DIRECT DEL /SERV	—	—	—	—	—	—	—	—	—	—	—
(2) LEO/PROP. SAT.	—	—	—	—	—	—	—	—	—	—	—
C. EARTH RETURN											
(1) DIRECT DEL/SERV	—	—	—	—	1	—	—	1	1	—	1
(2) LEO/PROP. SAT.	—	—	—	—	—	—	—	—	—	—	—
TOTAL USES	—	3	3	7	6	5	6	6	6	10	18
NO. UNITS REQD	—	1	1	2	—	—	—			—	—
REQD DELIVERY	—	1	—	1	—	—	—	Σ THRU '90 = 36		—	—

R81-1108-036D
1472-540(T)

C6 – SATELLITE SERVICES SYSTEM – EQUIPMENT STOWAGE PROVISIONS UTILIZATION

MISSION CATEGORY	FREQUENCY OF USE/YEAR										
	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92	'93
A. INITIAL LAUNCH											
(1) DIRECT DEL /SERV	–	–	–	–	–	–	–	–	–	–	–
(2) LEO/PROP. SAT.	–	–	–	–	–	–	–	–	–	–	–
(3) DoD	–	–	–	–	–	–	–	–	–	–	–
(4) PLANETARY	–	–	–	–	–	–	–	–	–	–	–
(5) GEO SAT.	–	–	–	–	–	–	–	–	–	–	–
(6) SORTIE	–	–	–	–	–	–	–	–	–	–	–
B. REVISIT											
(1) DIRECT DEL /SERV	–	–	1	2	4	7	9	9	9	11	12
(2) LEO/PROP. SAT.	–	–	–	1	7	8	10	12	11	7	12
C. EARTH RETURN											
(1) DIRECT DEL/SERV											
(2) LEO/PROP. SAT.											
TOTAL USES	–	–	1	3	11	15	19	21	20	18	24
NO. UNITS REQD	–	–	1	2	3	4	–	–	–	–	–
REQD DELIVERY	–	–	1	1	1	1	–			–	–
								Σ THRU '90 = 70			

R81-1108-029D
1472-541(T)

C7 – SATELLITE SERVICES SYSTEM – FLUID TRANSFER SYSTEM UTILIZATION

MISSION CATEGORY	FREQUENCY OF USE/YEAR										
	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92	'93
A. INITIAL LAUNCH											
(1) DIRECT DEL /SERV	–	–	–	–	–	–	–	–	–	–	–
(2) LEO/PROP. SAT.	–	–	–	–	–	–	–	–	–	–	–
(3) DoD	–	–	–	–	–	–	–	–	–	–	–
(4) PLANETARY	–	–	–	–	–	–	–	–	–	–	–
(5) GEO SAT.	–	–	–	–	–	–	–	–	–	–	–
(6) SORTIE	–	–	–	–	–	–	–	–	–	–	–
B. REVISIT											
(1) DIRECT DEL /SERV	–	–	1	2	4	7	9	9	9	11	12
(2) LEO/PROP. SAT.	–	–	–	1	7	8	10	12	11	7	12
C. EARTH RETURN											
(1) DIRECT DEL/SERV	–	–	–	–	–	–	–	–	–	–	–
(2) LEO/PROP. SAT.	–	–	–	–	–	–	–	–	–	–	–
TOTAL USES	–	–	1	3	11	15	19	21	20	18	24
NO. UNITS REQD	–	–	1	2	3	4	–			–	–
REQD DELIVERY	–	–	1	1	1	1	–	Σ THRU '90 = 70		–	–

R81-1108-030D
1472-542(T)

C8 – SATELLITE SERVICES SYSTEM – ATTITUDE TRANSFER PKG UTILIZATION

MISSION CATEGORY	FREQUENCY OF USE/YEAR										
	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92	'93
A. INITIAL LAUNCH											
(1) DIRECT DEL /SERV	–	1	–	–	–	–	–	–	–	–	–
(2) LEO/PROP. SAT.	–	1	1	–	–	–	–	–	–	–	–
(3) DoD	–	1	2	–	–	–	–	–	–	–	–
(4) PLANETARY	–	1	1	–	–	–	–	–	–	–	–
(5) GEO SAT.	2	3	3	–	–	–	–	–	–	–	–
(6) SORTIE	–	–	–	–	–	–	–	–	–	–	–
B. REVISIT											
(1) DIRECT DEL /SERV	–	–	–	–	–	–	–	–	–	–	–
(2) LEO/PROP SAT.	–	–	–	–	–	–	–	–	–	–	–
C. EARTH RETURN											
(1) DIRECT DEL/SERV	–	–	–	–	–	–	–	–	–	–	–
(2) LEO/PROP. SAT.	–	–	–	–	–	–	–	–	–	–	–
TOTAL USES	2	7	7	–	–	–	–	–	–	–	–
NO. UNITS REQD	1	2	–	–	–	–	–	–		–	–
REQD DELIVERY	1	1	–	–	–	–	–		Σ THRU '90 = 16		–

R81-1108-035D
1472-543(T)

C9 – SATELLITE SERVICES SYSTEM – NON-CONTAMINATING ACS UTILIZATION

MISSION CATEGORY	FREQUENCY OF USE/YEAR										
	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92	'93
A. INITIAL LAUNCH											
(1) DIRECT DEL /SERV											
(2) LEO/PROP. SAT.											
(3) DoD	←					NONE					→
(4) PLANETARY											
(5) GEO SAT.											
(6) SORTIE											
B. REVISIT											
(1) DIRECT DEL /SERV	–	–	1	1	2	2	1	1	3	4	5
(2) LEO/PROP. SAT.	–	–	–	1	2	1	3	3	5	1	5
C. EARTH RETURN											
(1) DIRECT DEL/SERV	–	–	1	–	–	1	1	1	–	1	–
(2) LEO/PROP. SAT.	–	–	–	3	1	1	–	1	5	2	1
TOTAL USES	–	–	2	5	5	5	5	6	13	8	11
NO. UNITS REQD	–	–	1	2	–	–	–		–	–	–
REQD DELIVERY	–	–	1	1	–	–	–	Σ THRU '90 = 28		–	–

R81-1108-034D
1472-544(T)

C10 – SATELLITE SERVICES SYSTEM – FSS (CRADLES A, A' & B) UTILIZATION

MISSION CATEGORY	FREQUENCY OF USE/YEAR										
	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92	'93
A. INITIAL LAUNCH	–	1	–	–	2	1	–	1	–	1	–
(1) DIRECT DEL /SERV	2	3	5	7	8	1	2	4	3	2	2
(2) LEO/PROP. SAT.	–	–	–	–	–	–	–	–	–	–	–
(3) DoD	–	–	–	–	–	–	–	–	–	–	–
(4) PLANETARY	–	–	–	14	16	21	21	26	20	20	31
(5) GEO SAT.	–	–	–	–	–	–	–	–	–	–	–
(6) SORTIE	–	–	–	–	–	–	–	–	–	–	–
B. REVISIT											
(1) DIRECT DEL /SERV	–	–	–	–	–	–	–	–	–	–	–
(2) LEO/PROP. SAT.	–	–	–	–	–	–	–	–	–	–	–
C. EARTH RETURN	–	–	–	–	–	–	–	–	–	–	–
(1) DIRECT DEL/SERV	–	–	–	–	–	–	–	–	1	1	–
(2) LEO/PROP. SAT.	–	1	–	3	2	2	2	5	4	1	–
TOTAL USES	2	5	5	24	28	25	25	36	28	25	33
NO. UNITS REQD	1	2	2	4	5	–	–		–	–	–
REQD DELIVERY	1	1	1	1	1	–	Σ THRU '90 = 150		–	–	–

R81-1108-027D
1472-545(T)

C11 – SATELLITE SERVICES SYSTEM – AFD CONTROLS & DISPLAY PANEL UTILIZATION

MISSION CATEGORY	FREQUENCY OF USE/YEAR										
	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92	'93
A. INITIAL LAUNCH	REQD FOR EACH OPERATIONAL MISSION										
(1) DIRECT DEL /SERV											
(2) LEO/PROP. SAT.											
(3) DoD											
(4) PLANETARY											
(5) GEO SAT.											
(6) SORTIE											
B. REVISIT											
(1) DIRECT DEL /SERV											
(2) LEO/PROP. SAT.											
C. EARTH RETURN											
(1) DIRECT DEL/SERV											
(2) LEO/PROP. SAT.											
TOTAL USES											
NO. UNITS REQD	2	4	6	—	—	—	—	Σ THRU '90 = 553		—	—
REQD DELIVERY	2	2	2	—	—	—	—			—	—

R81-1108-040D
1472-546(T)

C12 – SATELLITE SERVICES SYSTEM – MMU/WRU UTILIZATION (WITH END EFFECTOR)

MISSION CATEGORY	FREQUENCY OF USE/YEAR										
	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92	'93
A. INITIAL LAUNCH											
(1) DIRECT DEL /SERV	1	2	2	6	10	7	7	6	9	5	7
(2) LEO/PROP. SAT.	2	3	5	12	9	10	11	8	5	7	4
(3) DoD	5	6	15	17	12	11	7	7	7	8	4
(4) PLANETARY	–	3	3	6	1	1	2	–	1	1	4
(5) GEO SAT.	8	15	13	15	17	22	24	26	21	21	31
(6) SORTIE	5	13	16	21	19	21	18	18	18	19	17
B. REVISIT											
(1) DIRECT DEL /SERV	–	–	1	2	4	7	9	9	9	11	12
(2) LEO/PROP. SAT.	–	–	–	1	7	8	10	12	11	7	12
C. EARTH RETURN											
(1) DIRECT DEL/SERV	–	1	2	1	3	2	3	4	4	2	3
(2) LEO/PROP. SAT.	–	2	–	4	4	4	4	7	7	7	4
TOTAL USES	21	45	57	85	86	93	95	97	92	88	98
NO. UNITS REQD	–	–	–	–	–	–	–	–	–	–	–
REQD DELIVERY	–	–	–	–							–

(PART OF STD MMU SYSTEM – SEE MMU/WRU STAB. UTILIZATION FOR REQD NUMBER)

R81-1108-025D
1472-547(T)

C13 – SATELLITE SERVICES SYSTEM – MMU/WRU/UTILIZATION (WITH STABILIZER)

MISSION CATEGORY	FREQUENCY OF USE/YEAR										
	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92	'93
A. INITIAL LAUNCH											
(1) DIRECT DEL /SERV	2	3	4	6	10	7	7	6	9	5	7
(2) LEO/PROP. SAT.	4	6	10	24	18	20	22	16	10	14	8
(3) DoD	5	6	15	17	12	11	7	7	7	8	4
(4) PLANETARY	–	3	3	6	1	1	2	–	1	1	4
(5) GEO SAT.	8	15	13	15	17	22	24	26	21	21	31
(6) SORTIE	5	13	16	21	19	21	18	18	18	19	17
B. REVISIT											
(1) DIRECT DEL /SERV	–	–	2	2	4	7	9	9	9	11	12
(2) LEO/PROP. SAT.	–	–	–	1	7	8	10	12	11	7	12
C. EARTH RETURN											
(1) DIRECT DEL/SERV	–	2	4	2	6	4	5	7	6	4	5
(2) LEO/PROP. SAT.	–	3	–	5	7	7	7	13	14	14	8
TOTAL USES	24	51	67	99	101	108	111	114	106	104	108
NO. UNITS REQD	4	6	8	10	12	–	–			–	–
REQD DELIVERY	4	2	2	2	2	–	–	Σ THRU '90 = 675		–	–

R81-1108-024D
1472-548(T)

C14 – SATELLITE SERVICES SYSTEM – MMU/WRU POM ADAPTATION UTILIZATION

MISSION CATEGORY	FREQUENCY OF USE/YEAR										
	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92	'93
A. INITIAL LAUNCH											
(1) DIRECT DEL /SERV											
(2) LEO/PROP. SAT.											
(3) DoD											
(4) PLANETARY						NONE					
(5) GEO SAT.											
(6) SORTIE											
B. REVISIT											
(1) DIRECT DEL /SERV	–	–	–	–	1	1	2	5	4	2	1
(2) LEO/PROP. SAT.	–	–	–	1	1	–	–	–	–	–	–
C. EARTH RETURN											
(1) DIRECT DEL/SERV	–	–	1	–	–	1	–	–	1	2	1
(2) LEO/PROP. SAT.	–	2	–	3	–	1	1	–	1	–	–
TOTAL USES	–	2	1	4	2	3	3	5	6	4	2
NO. UNITS REQD	–	1	1	2	–	–	–		–	–	–
REQD DELIVERY	–	1	–	1	–	–	–	Σ THRU '90 = 20		–	–

R81-1108-039D
1472-549(T)

C15 – SATELLITE SERVICES SYSTEM – MMU/WRU PAYLOAD HANDLING UTILIZATION

MISSION CATEGORY	FREQUENCY OF USE/YEAR										
	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92	'93
A. INITIAL LAUNCH											
(1) DIRECT DEL /SERV	–	–	–	–	–	–	–	–	–	–	–
(2) LEO/PROP. SAT.	–	–	–	–	–	–	–	–	–	–	–
(3) DoD	–	–	–	–	–	–	–	–	–	–	–
(4) PLANETARY	–	–	–	–	–	–	–	–	–	–	–
(5) GEO SAT.	–	–	–	–	–	–	–	–	–	–	–
(6) SORTIE	–	–	–	–	–	–	–	–	–	–	–
B. REVISIT											
(1) DIRECT DEL /SERV	–	–	1	2	4	7	9	9	9	11	12
(2) LEO/PROP. SAT.	–	–	–	1	7	8	10	12	11	7	12
C. EARTH RETURN											
(1) DIRECT DEL/SERV	–	–	–	–	–	–	–	–	–	–	–
(2) LEO/PROP. SAT.	–	–	–	–	–	–	–	–	–	–	–
TOTAL USES	–	–	1	3	11	15	19	21	20	18	24
NO. UNITS REQD	–	–	1	–	2	3	4	–		–	–
REQD DELIVERY	–	–	1	1	1	1	–		Σ THRU '90 = 70		–

R81-1108-038D
1472-550(T)

C16 – SATELLITE SERVICES SYSTEM – MTV UTILIZATION

MISSION CATEGORY	FREQUENCY OF USE/YEAR										
	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92	'93
A. INITIAL LAUNCH											
(1) DIRECT DEL./SERV	–	–	–	–	–	–	–	–	–	–	–
(2) LEO/PROP. SAT.	–	–	–	–	–	–	–	–	–	–	–
(3) DoD	–	–	–	–	–	–	–	–	–	–	–
(4) PLANETARY	–	–	–	–	–	–	–	–	–	–	–
(5) GEO SAT.	–	–	–	–	–	–	–	–	–	–	–
(6) SORTIE	–	–	–	–	–	–	–	–	–	–	–
B. REVISIT											
(1) DIRECT DEL./SERV	–	–	1	2	4	7	9	9	9	11	11
(2) LEO/PROP. SAT.	–	–	–	1	7	8	10	12	11	7	12
C. EARTH RETURN											
(1) DIRECT DEL/SERV	–	1	2	1	3	2	3	4	4	2	3
(2) LEO/PROP. SAT.	–	2	–	4	4	4	4	7	7	7	4
TOTAL USES	–	3	3	8	18	21	26	32	31	27	30
NO. UNITS REQD	–	1	2	3	4	5	–	–		–	–
REQD DELIVERY	–	1	1	1	1	1	–	Σ THRU '90 = 111		–	–

R81-1108-023D
1472-551(T)

C17 – SATELLITE SERVICES SYSTEM – MTV POM ADAPTATION UTILIZATION

MISSION CATEGORY	FREQUENCY OF USE/YEAR										
	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92	'93
A. INITIAL LAUNCH											
(1) DIRECT DEL /SERV											
(2) LEO/PROP. SAT.											
(3) DoD	←					NONE					→
(4) PLANETARY											
(5) GEO SAT.											
(6) SORTIE											
B. REVISIT											
(1) DIRECT DEL /SERV	–	–	1	2	1	4	3	–	2	5	8
(2) LEO/PROP. SAT.	–	–	–	–	6	7	2	1	–	1	2
C. EARTH RETURN											
(1) DIRECT DEL/SERV	–	–	–	–	1	–	1	3	–	–	–
(2) LEO/PROP. SAT.	–	–	–	1	3	3	2	4	1	–	–
TOTAL USES	–	–	1	3	11	14	8	8	3	6	10
NO. UNITS REQD	–	–	1	2	–	–	–			–	–
REQD DELIVERY	–	–	1	1	–	–	–	Σ THRU '90 = 45		–	–

R81-1108-037D
1472-552(T)

C18 — SATELLITE SERVICES SYSTEM — SUN SHIELD UTILIZATION

MISSION CATEGORY	FREQUENCY OF USE/YEAR										
	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92	'93
A. INITIAL LAUNCH											
(1) DIRECT DEL /SERV	—	1	—	1	2	2	1	1	2	1	2
(2) LEO/PROP. SAT.	—	1	1	2	2	2	2	2	1	2	1
(3) DoD	—	1	2	2	2	2	2	2	1	2	1
(4) PLANETARY	—	1	1	1	—	—	1	—	—	—	1
(5) GEO SAT.	1	1	—	3	3	4	5	5	4	4	6
(6) SORTIE	—	—	—	—	—	—	—	—	—	—	—
B. REVISIT											
(1) DIRECT DEL /SERV	—	—	—	—	—	—	—	—	—	—	—
(2) LEO/PROP. SAT.	—	—	—	—	—	—	—	—	—	—	—
C. EARTH RETURN											
(1) DIRECT DEL/SERV	—	—	—	—	—	—	—	—	—	—	—
(2) LEO/PROP. SAT.	—	—	—	—	—	—	—	—	—	—	—
TOTAL USES	1	5	4	9	9	10	11	10	8	9	11
NO. UNITS REQD	1	2	—	3	—	—	—			—	—
REQD DELIVERY	1	1	—	1	—	—	—	Σ THRU '90 = 59		—	—

1472-553(T)
R81-1108-031D

C19 – SATELLITE SERVICES SYSTEM – ORBITAL STORAGE UTILIZATION

MISSION CATEGORY	FREQUENCY OF USE/YEAR										
	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92	'93
A. INITIAL LAUNCH											
(1) DIRECT DEL /SERV	–	1	–	1	2	2	1	1	2	1	2
(2) LEO/PROP. SAT.	–	1	1	2	2	2	2	2	1	2	1
(3) DoD	–	1	2	2	2	2	2	2	1	2	1
(4) PLANETARY	–	1	1	1	–	–	1	–	–	–	1
(5) GEO SAT.	2	3	3	3	3	4	5	5	4	4	6
(6) SORTIE	–	–	–	–	–	–	–	–	–	–	–
B. REVISIT											
(1) DIRECT DEL /SERV	–	–	–	1	1	1	2	2	2	2	2
(2) LEO/PROP. SAT.	–	–	–	–	2	2	2	2	2	2	2
C. EARTH RETURN											
(1) DIRECT DEL/SERV	–	–	–	–	–	–	–	–	–	–	–
(2) LEO/PROP. SAT	–	–	–	–	–	–	–	–	–	–	–
TOTAL USES	2	7	7	10	12	13	15	14	12	13	15
• NO. UNITS REQD	1	2	3	4	5	–	–		–	–	–
REQD DELIVERY	1	1	1	1	1	–		Σ THRU '90 = 80		–	–

R81-1108-032D
1472-554(T)

C20 – SATELLITE SERVICES SYSTEM – LIGHT ENHANCEMENT UTILIZATION

MISSION CATEGORY	FREQUENCY OF USE/YEAR										
	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92	'93
A. INITIAL LAUNCH											
(1) DIRECT DEL /SERV	–	1	–	1	2	2	1	1	2	1	2
(2) LEO/PROP. SAT.	–	1	1	2	2	2	2	2	1	2	1
(3) DoD	–	1	2	2	2	2	2	2	1	2	1
(4) PLANETARY	–	1	1	1	–	–	1	–	–	–	1
(5) GEO SAT.	2	3	3	3	3	4	5	5	4	4	6
(6) SORTIE	–	–	–	–	–	–	–	–	–	–	–
B. REVISIT											
(1) DIRECT DEL /SERV	–	–	–	1	1	1	2	2	2	2	2
(2) LEO/PROP. SAT.	–	–	–	–	2	2	2	2	2	2	2
C EARTH RETURN											
(1) DIRECT DEL/SERV	–	–	–	–	–	–	–	–	–	–	–
(2) LEO/PROP. SAT.	–	–	–	–	–	–	–	–	–	–	–
TOTAL USES	2	7	7	10	12	13	15	14	12	13	15
NO. UNITS REQD	3	6	9	15	25	35	45	55	60		
REQD DELIVERY	3	3	3	6	10	10	10	10	5		

Σ THRU '90 = 80 (FLIGHT CREWS)

1472-555(T)
R81-1108-033D

C21 – SATELLITE SERVICES SYSTEM – VSS UTILIZATION

MISSION CATEGORY	FREQUENCY OF USE/YEAR										
	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92	'93
A. INITIAL LAUNCH											
(1) DIRECT DEL /SERV	–	–	–	–	–	–	–	–	–	–	–
(2) LEO/PROP. SAT.	–	–	–	–	9	10	11	8	5	7	4
(3) DoD	–	–	–	–	–	–	–	–	–	–	–
(4) PLANETARY	–	–	–	–	–	–	–	–	–	–	–
(5) GEO SAT.	–	–	–	–	–	–	–	–	–	–	–
(6) SORTIE	–	–	–	–	–	–	–	–	–	–	–
B. REVISIT											
(1) DIRECT DEL /SERV	–	–	–	–	–	–	–	–	–	–	–
(2) LEO/PROP. SAT.	–	–	–	–	–	1	8	11	11	6	10
C. EARTH RETURN											
(1) DIRECT DEL/SERV	–	–	–	–	–	–	–	–	–	–	–
(2) LEO/PROP. SAT.	–	–	–	–	–	–	1	3	7	7	4
TOTAL USES	–	–	–	–	9	11	20	22	23	20	18
NO. UNITS REQD	–	–	–	–	2	3	4	–		–	–
REQD DELIVERY	–	–	–	–	2	1	1	Σ THRU '90 = 62		–	–

R81-1108-022D
1472-556(T)

NACA TN 565

TECHNICAL NOTES

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 565

INFLUENCE OF FUEL-OIL TEMPERATURE ON THE COMBUSTION IN A PRECHAMBER COMPRESSION-IGNITION ENGINE

By Harold C. Gerrish and Bruce E. Ayer
Langley Memorial Aeronautical Laboratory

Washington
April 1936

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

TECHNICAL NOTE NO. 565

INFLUENCE OF FUEL-OIL TEMPERATURE ON THE COMBUSTION IN A PRECHAMBER COMPRESSION-IGNITION ENGINE

By Harold C. Gerrish and Bruce E. Ayer

SUMMARY

The influence of fuel-oil temperature on combustion was investigated by injecting the fuel into the prechamber of a single-cylinder, 4-stroke-cycle, water-cooled, compression-ignition engine operating at 1,500 r.p.m. and at a compression ratio of 13.5. Indicator cards, exhaust-gas samples, and engine-performance data were obtained for changes in fuel temperature from 124° to 750° F. The injection characteristics of the fuel system and the appearance of the fuel spray were studied by injecting the fuel into the atmosphere. A common-rail fuel-injection system was used with a hydraulically controlled fuel-injection valve operating at a pressure of 8,800 pounds per square inch. The fuel was heated by passing it through an electric heater inserted between the pump and the injection valve.

The results showed that heating the fuel oil to 750° F. increased the injection period, changed the rate of injection, and eliminated the spray core. Engine tests showed that the ignition lag, rate of pressure rise, and maximum cylinder pressure were reduced. The indicated mean effective pressure, the fuel economy, and the thermal efficiency were slightly increased. Operation of the engine when the fuel was heated to 750° F. was smoother, the exhaust clearer, and the carbon formation in the combustion chamber considerably less than when the fuel was heated to 124° F.

INTRODUCTION

The present methods of proportioning the fuel to air and the utilization of air flow in combustion chambers to mix the fuel with the air have resulted in some improvement in the combustion process, but the fuel still burns

throughout a large portion of the power stroke. No great improvement in the engine performance can be expected as long as the fuel is burned late in the cycle.

Attempts to increase the thermal efficiency by injecting the fuel during the earlier part of the compression stroke and thus to obtain a more uniform mixture throughout the combustion chamber have not been satisfactory. The early injection resulted in the accumulation of a considerable quantity of fuel in the combustion chamber and, upon ignition, high cylinder pressures were developed, knocking occurred, and the engine operation was rough.

A theoretical analysis shows that, for the same maximum cylinder pressure, an engine operating on the constant-pressure combustion cycle is more efficient than one operating on the constant-volume cycle. A method of obtaining the constant-pressure combustion cycle is to reduce the ignition lag to zero so that the rate of injection will control the rate of burning, to inject the fuel at such a rate that constant pressure may be maintained, and to insure that the necessary air for combustion is available at the proper time.

It should be possible to reduce the ignition lag by reducing the time required in the engine cylinder to heat the fuel to its ignition temperature. Various methods of raising the temperature of the fuel have been proposed (references 1 and 2). Methods of heating the fuel directly have utilized the heat of the exhaust gases as well as part of the heat developed during combustion. Hawkes (reference 3) preheated the fuel by passing it through an oil heater in the exhaust stack of the engine.

The object of this investigation was to determine the effect of raising the fuel-oil temperature prior to injection on the injection characteristics, the ignition lag, the combustion, and the engine performance.

APPARATUS

The single-cylinder, 4-stroke-cycle, water-cooled test engine used in this investigation is shown in figure 1. The N.A.C.A. universal test-engine base and cylinder were used with the cylinder head included in figure 2.

The following table gives the special characteristics of the engine, the test conditions, and the fuel used.

Engine	5-inch bore, 7-inch stroke.
Combustion chamber ---	Disk, prechamber, 2-3/4 inches in diameter and 1 inch thick containing 50 percent of the clearance volume. Chamber connected to cylinder by a 9/16-inch-diameter passage flared at both ends.
Engine speed ---------	1,500 r.p.m.
Compression ratio ----	13.5.
Start of injection ---	Top center (1 crankshaft degree late for 750° F. fuel temperature).
Fuel ------------------	Auto Diesel fuel, 41 seconds Saybolt universal viscosity at 80° F. Distillation curve (A.S.T.M.) shown in figure 3.
Fuel quantity --------	0.0003 pound per cycle, 4 percent excess air.
Fuel-injection pressure ---------------	8,800 pounds per square inch.
Fuel nozzle ----------	Single round-hole orifice, 0.060-inch diameter, length-diameter ratio, 4.

Previous tests with heated fuel using a displacement-type fuel pump and an automatic fuel-injection valve indicated the necessity of reducing the injection period and maintaining an accurate control of the start of injection. Other factors encountered were warping of the valve parts and excessive leakage of fuel past the lapped portion of the valve stem at the higher fuel temperatures.

The fuel system used in these tests is shown mounted on the test engine in figure 1 and diagrammatically in

figure 2. It consists of a modified commercial fuel-injection pump, a suitable injection valve, and an electric heater. The fuel-injection system has a low- and a high-pressure fuel-oil circuit. The low-pressure circuit has two small gear pumps: the primary pump that supplies oil to three uniformly phased high-pressure plunger pumps and the sump pump that returns any fuel oil passing through the various pressure seals to the primary fuel supply. The fuel supplied to the high-pressure plungers is maintained under pressure by a regulating valve in the pump body. Excess oil from the primary pump and the oil collected by the sump pump is bypassed through the crankcase of the fuel pump for lubricating purposes and through an oil cooler to the oil reservoir on the fuel-weighing stand.

The high-pressure oil circuit consists of three uniformly phased plunger pumps, which supply oil to the maximum-fuel-pressure regulating valve, the injection-control valve, and the injection valve. Pressure is maintained in this circuit by the maximum-fuel-pressure regulating valve. Excess oil passes through this valve and the oil cooler to the reservoir on the fuel stand. The oil to be injected passes through the safety check valve, the electric heater, the auxiliary control valve, and into the injection valve. The oil used to control injection maintains pressure on the injection-valve stem between injections and replaces that quantity of oil released by the operation of the injection-control valve.

The injection-control valve shown diagrammatically in figure 2 consists of a lapped spindle rotating in a valve body. The spindle has a set of ports located on its circumference, which at the proper time uncover a port in the valve body connected to the injection-control tube. The pressure on top of the injection-valve stem is released when port 2 sufficiently overlaps port 3. The high-pressure fuel oil acting on a small differential annular area at the nozzle end of the valve stem raises the valve stem and discharges fuel into the combustion chamber. This discharge of fuel continues until port 2 sufficiently overlaps the high-pressure fuel-oil supply in port 4, which produces a pressure wave that returns the injection-valve stem to its seat and stops the injection. The quantity of fuel discharged is controlled by manually adjusting the interval between ports 3 and 4.

The maximum-fuel-pressure regulating valve shown in figure 2 is the usual spring-loaded automatic injection

valve with a single round-hole orifice nozzle. The injection pressure can be adjusted during operation to any desired value by varying the spring tension.

The injection valve shown in figure 4 was designed to operate at an injection pressure of 10,000 pounds per square inch and at a fuel temperature of 1,000° F.; it has the usual lapped clearance between the valve stem and the sleeve. In order to maintain the lapped clearance, the heated fuel, in its passage through the valve, transmitted heat to the stem through the sleeve. This method maintains a positive clearance between the stem and sleeve at all times during the heating process. A special key, clamped between the valve body and the nozzle, allowed the stem and sleeve to expand but prevented the sleeve from turning in the body. The high operating stress caused by the injection pressure together with the high fuel temperature necessitated the construction of the injection-valve stem, sleeve, nozzle, and stem-stop of steel having a high tungsten content. This steel had sufficient hardness at the high fuel temperature to prevent galling the stem with the sleeve or peening the stem at the seat and the stem-stop.

The electric heater is shown in figure 5 with part of the insulation removed. It was composed of 10 feet of seamless carbon steel tubing, 1/4-inch outside diameter and 1/8-inch bore, wound in the form of a close-coiled helical spring, 4-1/2 inches in diameter. The consecutive coils were lightly tack-welded together at intervals to prevent any springing of the unit caused by pulsating high-pressure fuel oil. The heating element was made of No. 15 B & S gage nichrome IV wire wound in a small helix and wrapped around the tubing. The wire was insulated from the tubing by porcelain insulators and alundum cement. The heating element was placed in a sheet-iron container and the intervening space filled with mineral wool.

METHOD

The effect of fuel temperature on the start of injection was determined by mounting the injection system on the engine, allowing the fuel valve to discharge into the exhaust system, and observing the development of the fuel spray with the Stroborama. The engine was motored at the test speed of 1,500 r.p.m. and the spray characteristics

were obtained for several changes in fuel temperature from 124° to 600° F. An injection pressure of 8,800 pounds per square inch was found necessary with the present valve design to insure regular injection at all fuel temperatures.

Engine tests were made with the injection valve in the top hole of the precombustion chamber. (See fig. 2.) As soon as test conditions became stabilized, the usual engine data, temperatures of the fuel system, exhaust temperature, indicator cards, and samples of the exhaust gases were obtained. As no trouble was encountered with the injection system for fuel temperatures up to 600° F., the temperature of the fuel was increased to 750° F. and the data previously mentioned were obtained.

In order to obtain the necessary correction to the injection advance angle for the 750° F. fuel, the injection valve was removed from the combustion chamber and allowed to discharge fuel into the exhaust system. The start of injection for this fuel temperature was determined but with a slightly larger fuel quantity than that used in the engine tests. The heating unit failed, however, and therefore the start of injection obtained at the larger fuel quantity was considered to be the actual start of injection which, according to other data, is not critical with fuel quantity.

The heat input to the electric heater was measured by a voltmeter and an ammeter. The quantity of heat was controlled by water-cooled rheostats. As the heat losses from the heater were excessive, the voltmeter and ammeter readings were used only as a guide for regulating the temperature at the injection valve.

Exhaust-gas samples taken through a 1/4-inch steel tube inserted in the center of the exhaust stack approximately 1 inch from the exhaust valve were completely analyzed by means of a modified Bureau of Mines gas-analysis apparatus (reference 4).

The start of injection, the spray development, the stop of injection, and the location of the top center lines on the indicator cards were determined by means of a Stroborama. A modified Farnboro indicator (references 5 and 6) was used to record the variations of pressure in the precombustion chamber. (See fig. 2 for valve location.) The maximum explosion pressure in this chamber was determined from the indicator cards; the maximum cylinder

pressure was recorded by means of a Farnboro-type valve in the cylinder head. (See fig. 2.)

Various attempts to measure the actual temperature of the fuel oil at the high temperature and pressure used were unsatisfactory, and the temperature of the injection tube close to the injection valve as indicated by a thermocouple T (fig. 2) was considered to be the temperature of the fuel. This method of indicating the fuel temperature was satisfactory for these tests but was not considered sufficiently accurate to correct the engine-performance data for the increase in thermal energy of the fuel.

EFFECT OF FUEL-OIL TEMPERATURE ON INJECTION CHARACTERISTICS

The preliminary tests with this fuel-injection system indicated the necessity for cooling the injection-control tube. Without the water jacket the start of injection was retarded 30 crankshaft degrees at an engine speed of 1,500 r.p.m. when the fuel was heated to 800° F. When the water jacket was used, this interval was reduced to 3 crankshaft degrees. The change in the start of injection was caused by the large increase in the compressibility of the fuel oil, which affected the velocity of the pressure wave through the injection-control tube. The increasing temperature in the control tube was caused by the conduction of heat from the injection valve and not by the alternate compression and expansion of the fuel oil in the tube.

The action of the injection-valve stem for the test conditions further indicates the compressibility effect. With the 124° F. fuel the valve stem did not lift the 0.030 inch allowed by the stem stop, as indicated by the lack of markings on the top of the stem. Apparently the orifice was sufficiently large to keep the restricting point at the seat for this fuel-injection process. With the 750° F. fuel, however, definite markings appeared on the top of the stem, in addition to an increase in the injection period of 3 crankshaft degrees, indicating a large change in the specific volume of fuel passing through the orifice for similar pressure conditions.

The effect of temperature on the compressibility of the oil was further shown in the development of the fuel

spray. The 124° F. fuel-spray envelope had a cone angle of less than 10°, within which was a concentrated core; the spray envelope at a fuel temperature of 750° F. had a cone angle of approximately 30° with no perceptible core, the entire spray being a well-defined billowy cloud. A definite increase in the spray cone angle occurred with the increase of the fuel temperature to above 400° F.

During the preliminary tests with a spring-loaded automatic injection valve operating at an injection pressure of 3,500 pounds per square inch and a fuel temperature of 670° F., the spray issued from the valve as a blue haze, leaving the nozzle dry. A few inches from the nozzle, the haze gradually formed a fleecy white cloud. This condition was not attained in the tests using the hydraulic-injection system because of the much higher injection pressures.

The start and stop of injection with 124° F. fuel was characterized by a slight dribbling of oil; whereas with the fuel heated to temperatures above 400° F. the start and stop were well defined. At the highest fuel temperature with the fuel injecting into the atmosphere, the start was characterized by a sharp crack, and the fuel expanded from the 0.060-inch orifice to approximately 1/4-inch diameter instantly at the orifice.

EFFECT OF FUEL-OIL TEMPERATURE ON THE EFFECTIVE IGNITION LAG

Effective ignition lag was determined by the method used in reference 7 and is defined as the period between the start of injection, and the time when 4.0×10^{-6} pounds of fuel has been effectively burned, as determined from the analysis of the indicator card. The effective-ignition-lag curve shown in figure 6 shows that the lag increased up to a fuel temperature of 300° F. and then decreased with an increase in the fuel temperature. It is believed that the increase in ignition lag is caused by the progressively finer atomization of a larger portion of the fuel spray, which results from the decreasing viscosity and surface tension of the fuel oil. The increase in the surface-volume ratio of the drops also produces a local decrease in temperature greater than that normally occurring with the 124° F. fuel. As soon as the fuel oil is sufficiently heated to offset this cooling, the ignition lag starts to

decrease. It is significant that the fuel-spray envelope begins to show change at this time. The decrease with fuel temperatures greater than 300° F. is believed to be principally due to either the decreased difference between the fuel temperature at injection and its auto-ignition temperature, to the finer atomization and dispersion of the fuel, which increases the surface-volume ratio of the drops and their rate of heat absorption, or to both these factors.

EFFECT OF FUEL-OIL TEMPERATURE ON COMBUSTION

The effects of heating fuel oil from 124° to 750° F. on the shapes of the indicator cards are shown in figure 7. Heating the fuel oil did not affect the dispersion of the points that form the diagrams. The cards show that heating the fuel causes the breakaway of the combustion from the compression to occur nearer top center and the pressure rise and the maximum pressure to be less.

The difference in the injection period and in the combustion of the fuel for the two conditions is quite marked (fig. 8). Although the start of injection is nearly the same for both fuel temperatures, the stop of injection is different. For the 124° F. fuel the injection is practically complete before breakaway occurs, while for the 750° F. fuel it continues into the region of maximum pressure. The development of the initial pressure rise for the 750° F. fuel is more desirable than that for the 124° F. fuel since the average rate of pressure rise from ignition to maximum explosion pressure is only 30 pounds per square inch per degree, whereas with the 124° F. fuel it is 50 pounds per square inch per degree.

A thermodynamic analysis of the indicator cards was made to obtain information on the evolution of heat when fuel oil heated to 124° and to 750° F. was used. Figure 9 shows the amount of fuel effectively burned. By "effectively burned" is meant the amount of fuel required to produce the change in enthalpy indicated by the pressure-time cards.

Although the start of the injection of the 750° F. fuel was later than that of the 124° F. fuel by 1 crankshaft degree, the former fuel started to burn approximately 3 crankshaft degrees earlier and combustion had proceeded to a large extent before the completion of the injection.

With the latter fuel, combustion had just started at the end of injection. The late start of combustion with the 124° F. fuel results in the formation of a large amount of combustible mixture in the engine and, upon ignition, causes high maximum cylinder pressures accompanied by a heavy metallic knock. The early combustion of the 750° F. fuel maintains lower rates of pressure rise with less intense knock and leads to a more desirable form of indicator card.

The total effective fuel burned up to the position of maximum explosion pressure was approximately the same with the 750° F. fuel as with the 124° F. fuel, but the maximum explosion pressure as determined from the indicator cards was approximately 70 pounds per square inch less with the 750° F. fuel. Although the maximum pressure was lower, the energy released early in the power stroke resulted in a slight improvement in the performance of the engine.

It was expected that the high residual air flow in the prechamber together with the 750° F. fuel would materially reduce the quantity of fuel burned late in the stroke, but figure 9 shows that the quantity burned after maximum pressure was approximately the same as that with the 124° F. fuel. Apparently the heating of the fuel had the greatest effect during the first part of the combustion period in this particular combustion chamber. It is not known whether the 750° F. fuel would have a greater effect on combustion late in the stroke if it had been injected into all instead of less than half the combustion air. It seems that the time utilized in forming the excessively rich mixture in the prechamber could have been advantageously used to mix the fuel with the air, since the tremendous volume of the heated fuel spray would assist the mixing process much better than could a spray with a central core.

Additional information on the combustion of the 750° F. fuel was obtained by examining the combustion chamber after several hours of engine operation. No appreciable amount of carbon was found in the combustion chamber. The deposit on the piston crown was so thin that it did not obscure the polish on the exposed surface. In the case of the 124° F. fuel, the carbon formation was very pronounced even after a much shorter period of operation. The cause of the lack of carbon deposit when using the 750° F. fuel is not apparent, inasmuch as chemical analysis of the exhaust gases showed practically no difference in composi-

tion, which indicates that the same amount of carbon was burned in both cases.

It is not definitely known whether the high temperature had any effect on the composition of the fuel because the heater failed before a sample of the fuel could be obtained for analysis. It is believed, however, that no change in the composition of the fuel occurred because of the small amount of time that the fuel was exposed to the high temperature, approximately 12 seconds, and because of the high pressure maintained on the fuel at all times. An examination of the inside of the injection tube, after 14 hours of operation with fuel above a temperature of 300° F. and 9 hours above a temperature of 700° F., showed no carbon deposits on the walls.

EFFECT OF FUEL-OIL TEMPERATURE ON ENGINE PERFORMANCE

Figure 6 shows the effect of heating fuel on the performance of the engine. Only a slight improvement in the power and economy is indicated. Since only one size of connecting passage between the combustion chamber and the cylinder and one form and size of prechamber was used in this investigation, it is not known whether some other combination of these factors would have shown a greater improvement. As the investigation was primarily concerned with the control of the initial combustion, the various combinations were not studied.

Heating the fuel oil improved the operation of the engine. The combustion knock was perceptibly less and the exhaust showed less flame than that obtained with 124° F. fuel. Smoke was present in the exhaust under all conditions as would be expected with only 4 percent of excess air but, as the fuel temperature was increased, the amount of smoke became less and intermittently there were clear periods. The tendency of the knock to decrease with increasing fuel temperature was probably caused by the changing rate of injection, which was indicated by the increase of the injection period and by the change in the rate during this period as previously explained. The decreased smoke and flame in the exhaust indicated a change in the combustion process with increased fuel temperature. Because of the limited nature of these tests, this phase of the problem was not investigated.

Hawkes (reference 3) reported a decrease in engine performance with an increase in fuel temperature up to 400° F. This decrease in engine performance was probably due to the retarded injection accompanying the preheated fuel because the authors found, during some preliminary experiments with heated fuel and a displacement-type fuel-injection system, that injection was materially retarded with an increase in fuel temperature if the injection timing was not advanced to compensate for the increased compressibility of the fuel.

CONCLUSIONS

From the preliminary tests of a prechamber compression-ignition engine using heated fuel oil and a nozzle with a 0.060-inch-diameter orifice, it was found that with increasing fuel temperatures:

1. The injection period was increased, the average rate of injection of the fuel was decreased, the spray core was eliminated, and the entire spray was a white cloud.

2. The ignition lag, rate of pressure rise, and cylinder pressures were reduced.

3. The mean effective pressure and the thermal efficiency were slightly improved.

4. The operation of the engine was smoother, the exhaust was clearer, and the carbon formation in the combustion chamber was considerably less.

Langley Memorial Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., March 26, 1936.

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4. Gerrish, Harold C., and Tessmann, Arthur M.: Relation of Hydrogen and Methane to Carbon Monoxide in Exhaust Gases from Internal-Combustion Engines. T.R. No. 476, N.A.C.A., 1933.

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7. Gerrish, Harold C., and Voss, Fred: Influence of Several Factors on Ignition Lag in a Compression-Ignition Engine. T.N. No. 434, N.A.C.A., 1932.

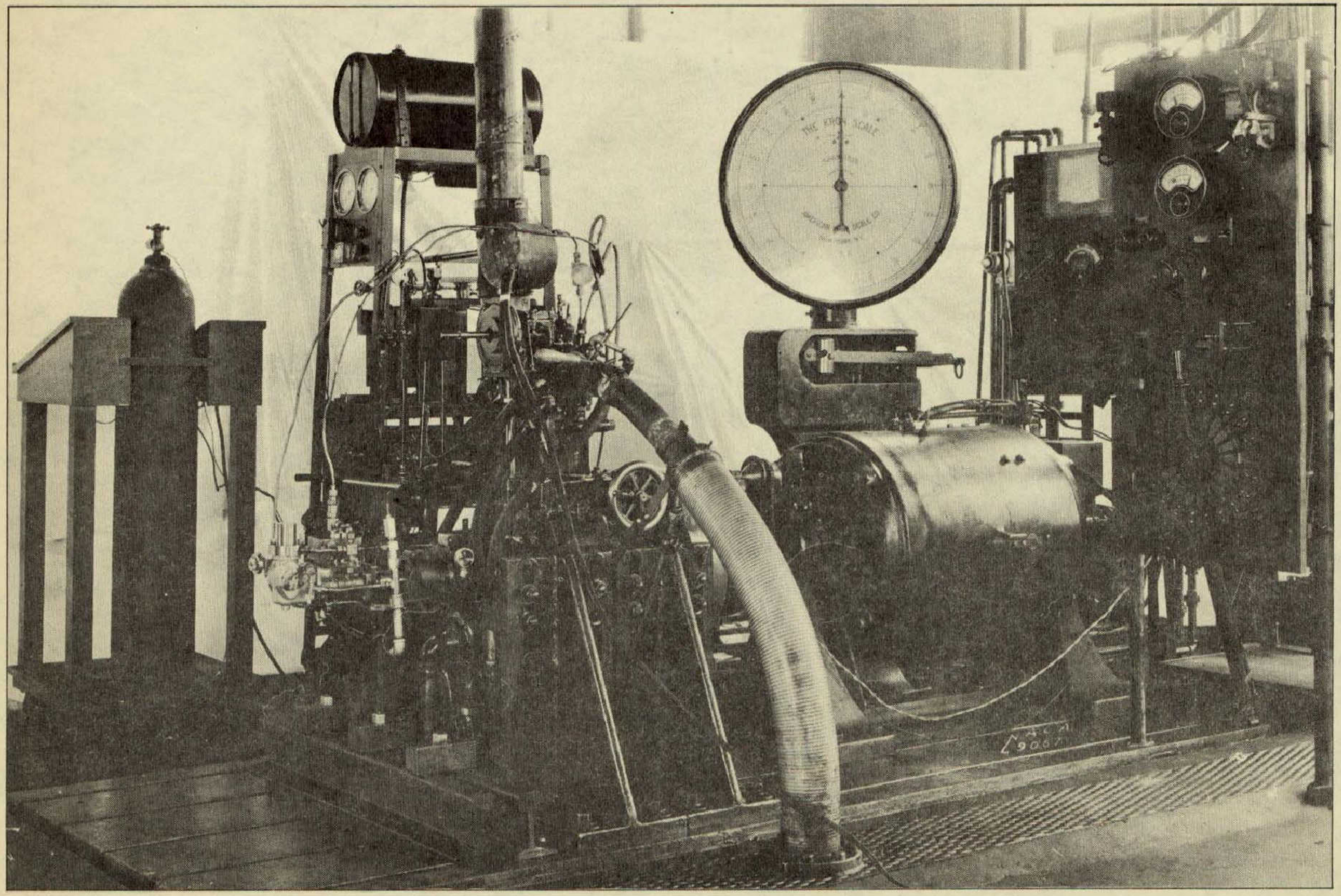

Figure 1. Single-cylinder engine and equipment.

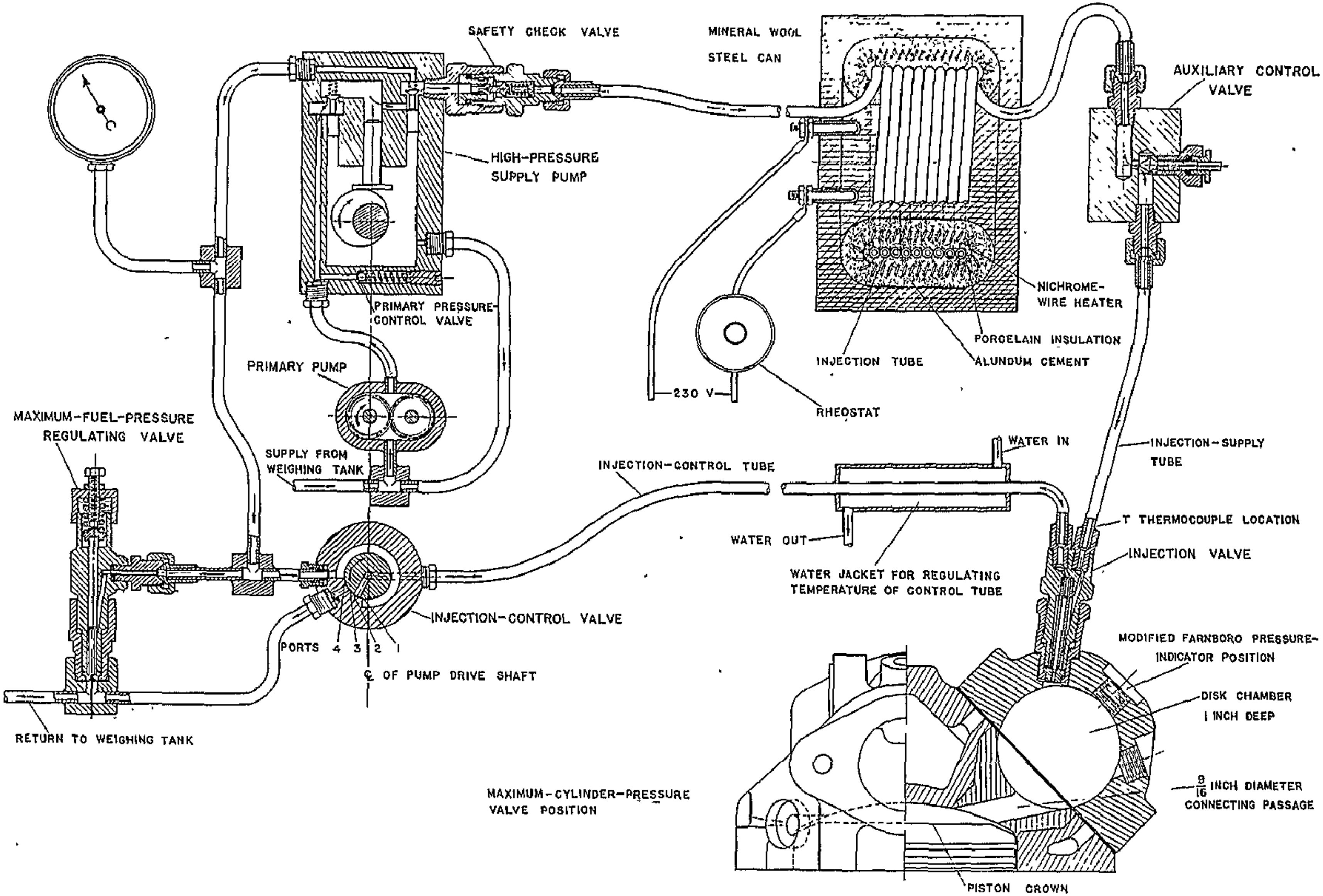

FIGURE 2. DIAGRAMMATIC SKETCH OF FUEL SYSTEM AND COMBUSTION CHAMBER

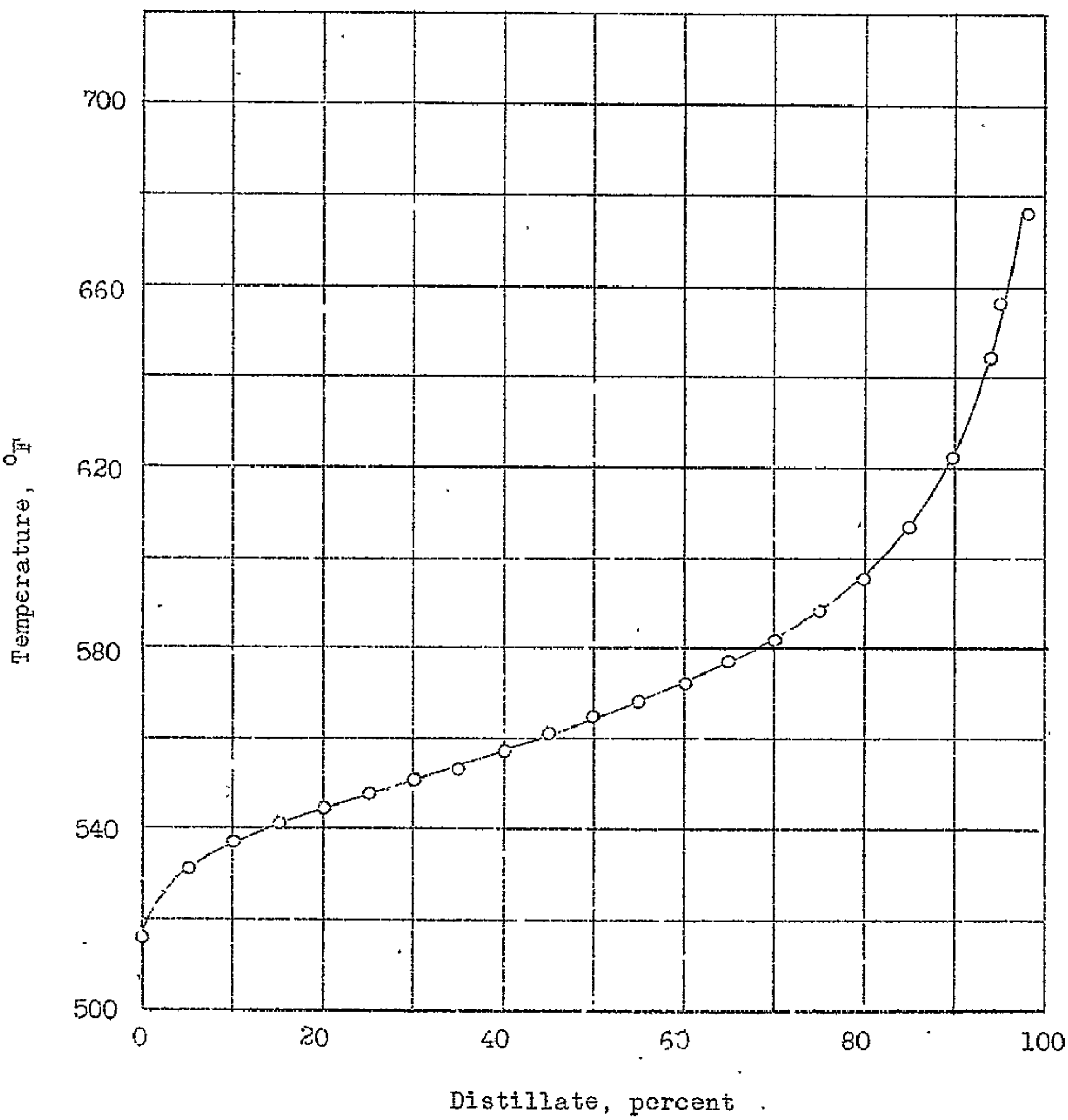

Figure 3.- Auto Diesel fuel oil distillation curve (A.S.T.M.).

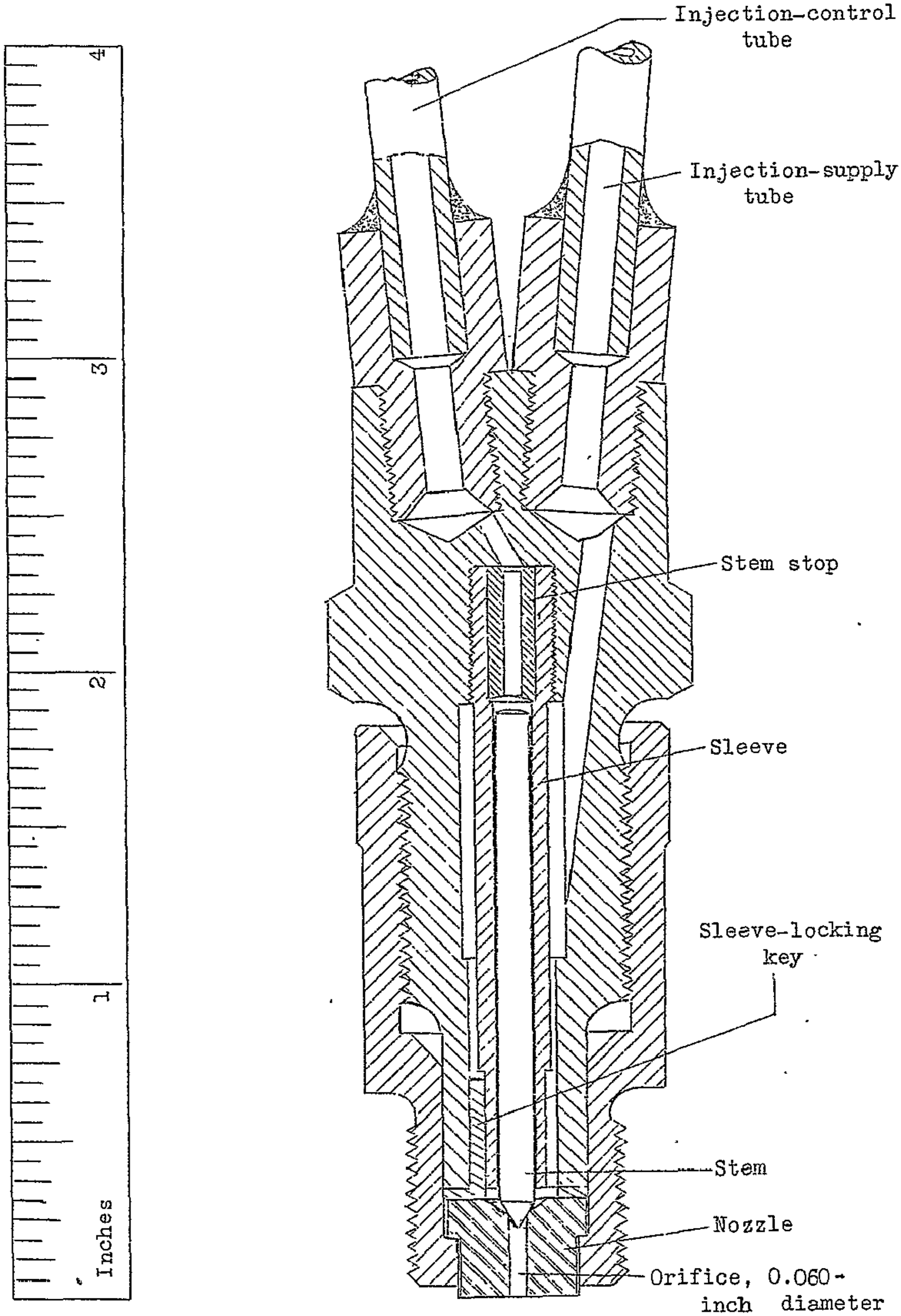

Figure 4.- Fuel-injection-valve assembly

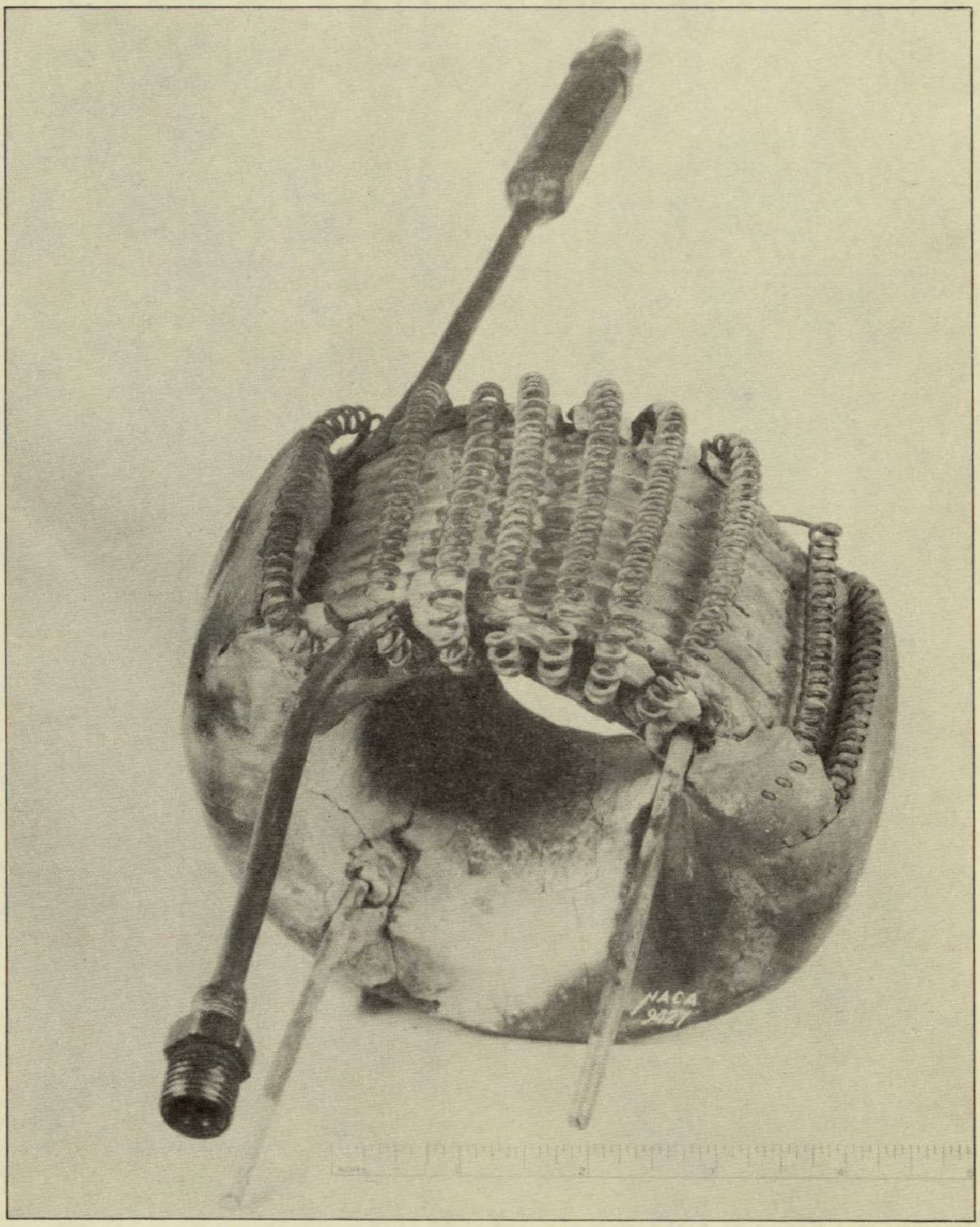

Figure 5.- Fuel heater construction.

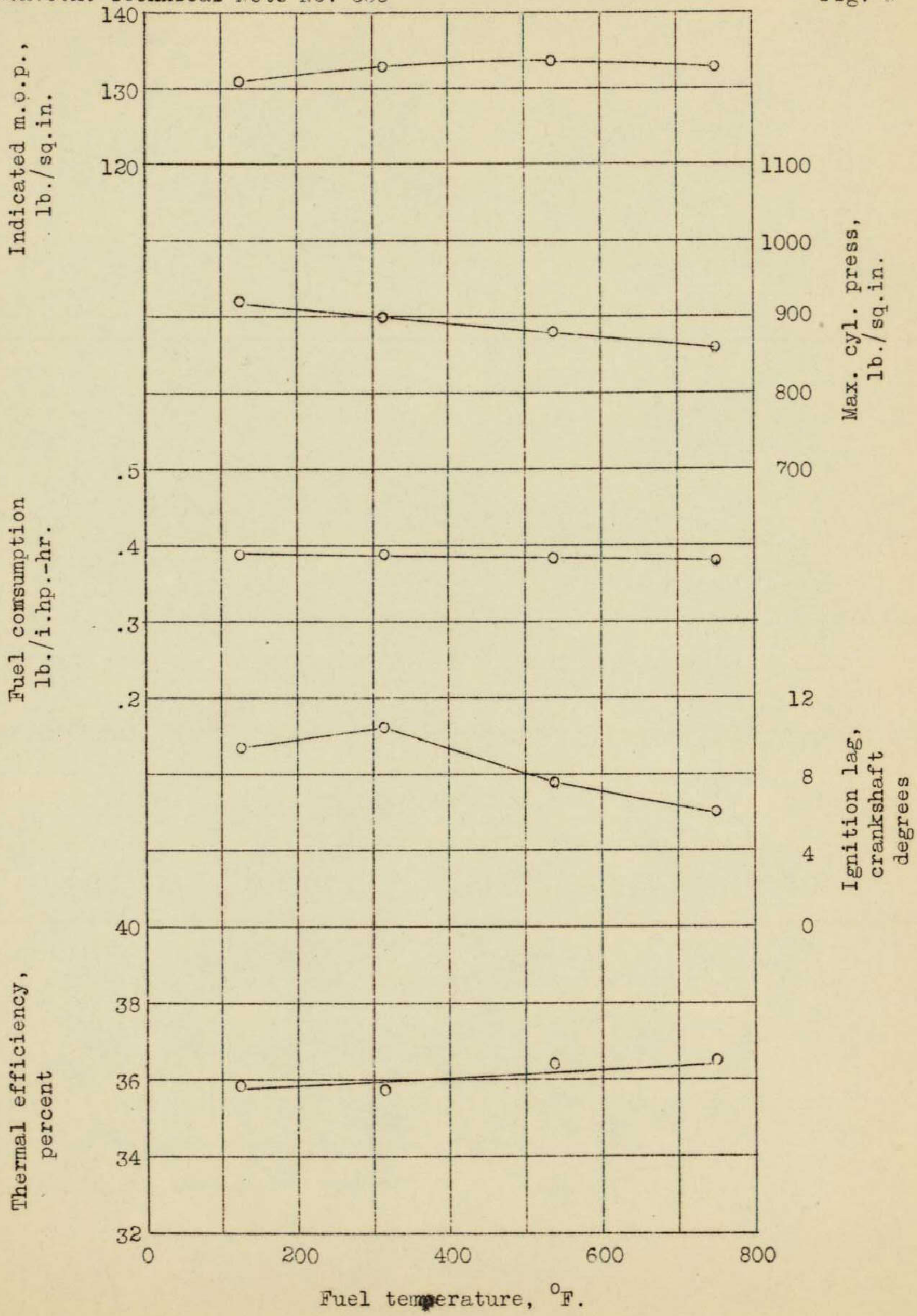

Figure 6.- Effect of fuel temperature on engine performance.

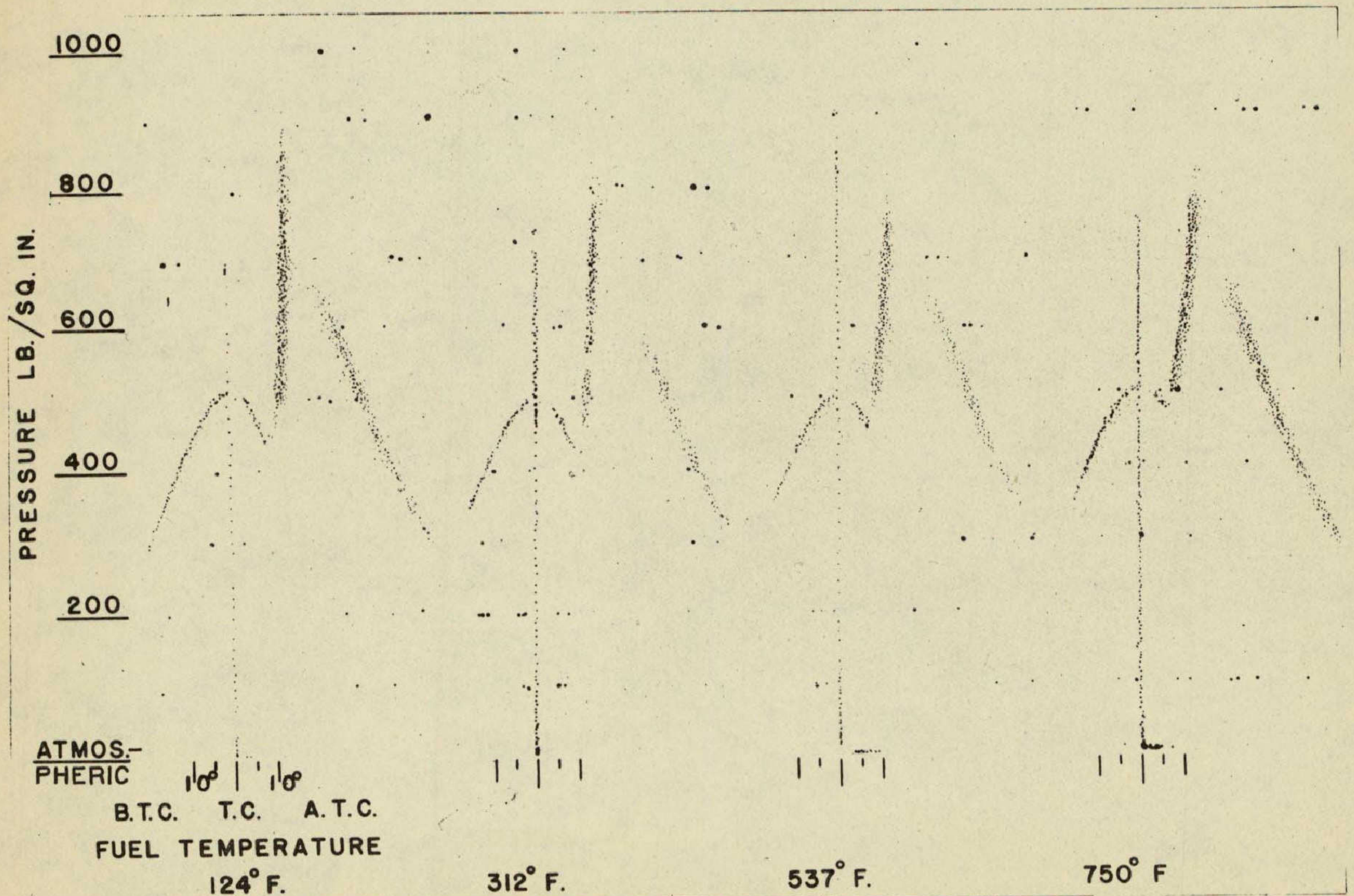

Figure 7.- Indicator cards obtained at different fuel temperatures.

20

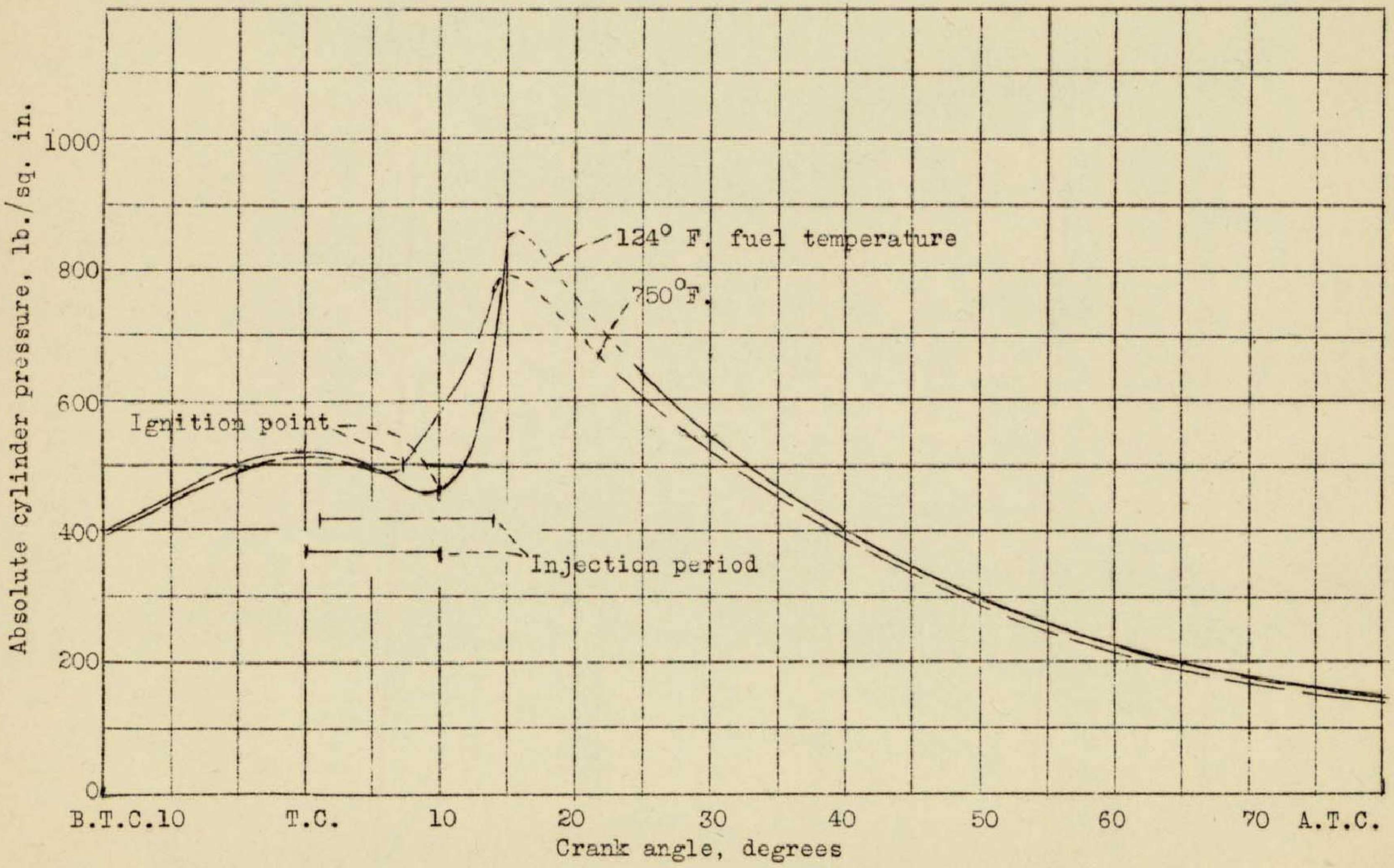

Figure 8.- Comparison of indicator cards obtained with heated fuel.

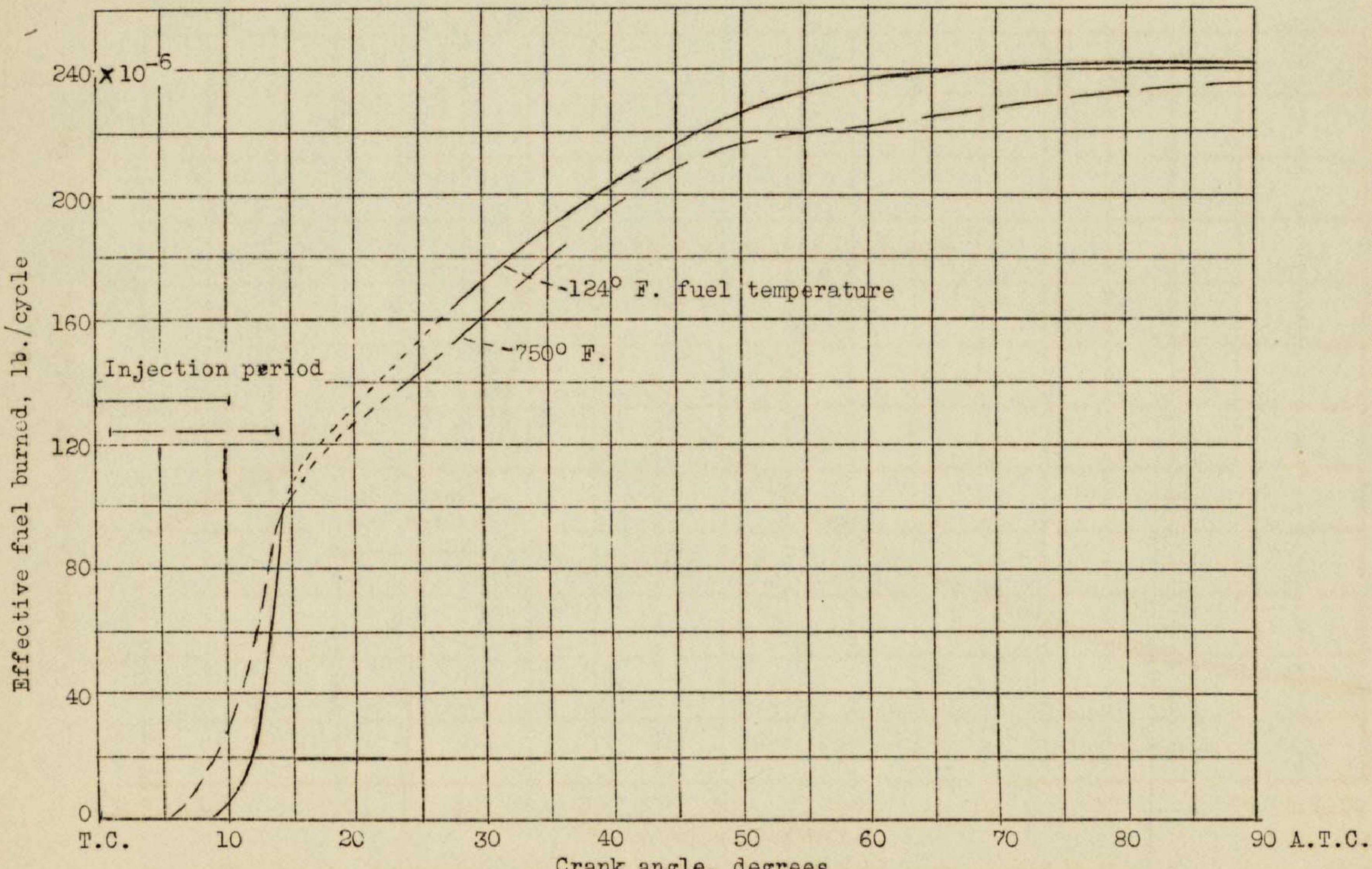

Figure 9.- Effect of fuel temperature on combustion.

22

N82-27350

Case File

B1 – INITIAL LAUNCH – EQUIPMENT UTILIZATION SUMMARY – DIRECT DELIVERY/SERVICING SATELLITE MISSIONS ('83 TO '85)
RMS PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT											OPTIONAL EQUIPMENT			
1983 MISSIONS	RETENTION STRUCTURE	TILT TABLE	SPIN TABLE	RMS	PIDA	MFR/RMS	MMU/WRU WITH END EFFECTOR	MMU/WRU WITH STABILIZER	HPA	MTV	VSS	SUN SHIELD	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCEMENT
SPAS-01 STS PALLET SAT.	X			X		X	X	X^2							
1984 MISSIONS															
SPACE TELESCOPE (A-3)		X		X		X	X	X							
LDEF (01-10)	X			X		X	X	X^2							
OPTIONAL SERVICE MISSIONS												X	X	X	X
1985 MISSIONS															
SPAS-01 STS PALLET SAT.	X			X		X	X	X^2							
GRO-GAMMA RAY OBSERV (A-7)	X			X		X	X	X^2							

R81-1108-065D-067D
1472-503(T)

NOTE: EXPONENT INDICATES NUMBER OF USES

FOLDOUT FRAME

2 FOLDOUT FRAME

B2 – INITIAL LAUNCH – EQUIPMENT UTILIZATION SUMMARY – DIRECT DELIVERY/SERVICING SATELLITE MISSIONS ('86 TO '88)
HPA PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT												OPTIONAL EQUIPMENT		
	RETENTION STRUCTURE	TILT TABLE	SPIN TABLE	RMS	PIDA	MFR/RMS	MMU/WRU		HPA	MTV	VSS	SUN SHIELD	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCEMENT
1986 MISSIONS							WITH END EFFECTOR	WITH STABILIZER							
LDEF (01-10)	X			X		X	X	X	X						
SASP-SCI & APP SP PLAT (U-7 & L-2)	X			X		X	X	X	X						
25kW PWR MOD. (U-8)	X			X	X	X	X	X	X						
LG STRUCT CONSTR (U-6)	X			X		X	X	X	X						
MAT'LS EXPERIMENT CARRIER (U-9 & -10)	X			X		X	X	X	X						
SUBSAT FACILITY (S-9)	X			X		X	X	X	X						
OPTIONAL SERVICE MISSIONS												X	X		X
1987 MISSIONS															
SPAS-01 STS PALLET SAT.	X			X		X	X	X	X						
MAT'LS EXPERIMENT CARRIER (U-9 & -10)	X			X		X	X	X	X						
SUBSAT FACILITY (S-9)	X			X		X	X	X	X						
AXAF-ADV X-RAY ASTRO (A-9)				X	X	X	X	X	X						
CRO-COSMIC RAY OBSER (A-13)	X			X		X	X	X	X						
GRAVITY PROBE B (A-8)	X			X		X	X	X	X						
POLAIRE (LEP)	X			X		X	X	X	X						
COASTAL SAT. (NAS)	X			X		X	X	X	X						
SOC-SP OPS CTR (5 YR)				X^2	X^2	X^2	X^2	X^2	X^2						
OPTIONAL SERVICE MISSIONS												X^2	X^2		X^2
1988 MISSIONS															
SASP-SCI & APP SP PLAT (U-7 & L-2)	X			X		X	X	X	X						
25 kW PWR MOD. (U-8)				X	X	X	X	X	X						
MAG FIELD SURV B(R-7)	X			X		X	X	X	X						
MAT'LS EXPERIMENT CARRIER (U-9 & -10)	X			X		X	X	X	X						
SUBSAT FACILITY (S-9)	X			X		X	X	X	X						
SOC-SP OPS CTR (5 YR.)				X^2	X^2	X^2	X^2	X^2	X^2						
OPTIONAL SERVICE MISSIONS												X^2	X^2		X^2

R81-1108-068D-070D
1472-504(T)

NOTE: EXPONENT INDICATES NUMBER OF USES

FOLDOUT FRAME 1

2 FOLDOUT FRAME

B3 – INITIAL LAUNCH – EQUIPMENT UTILIZATION SUMMARY – DIRECT DELIVERY/SERVICING SATELLITE MISSIONS ('89 TO '92)
HPA PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT											OPTIONAL EQUIPMENT			
	RETENTION STRUCTURE	TILT TABLE	SPIN TABLE	RMS	PIDA	MFR/RMS	MMU/WRU		HPA	MTV	VSS	SUN SHIELD	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCE-MENT
							WITH END EFFECTOR	WITH STABILIZER							
1989 MISSIONS															
SPAS-01 STS PALLET SAT.	X			X		X	X	X	X						
LDEF (01-10)	X			X		X	X	X	X						
MAT'LS EXPERIMENT CARRIER (U-9 & -10)	X			X		X	X	X	X						
SUBSAT FACILITY (S-9)	X			X		X	X	X	X						
SOC-SP OPS CTR (5 YR)				X	X	X	X	X	X						
OCEAN RESEARCH SAR (E-11)				X	X	X	X	X	X						
HVY NUCLI EXPL (GSF)	X			X		X	X	X	X						
OPTIONAL SERVICE MISSIONS												X	X		X
1990 MISSIONS															
SPACE TELESCOPE (A-3)		X		X		X	X	X	X						
MAT'LS EXPERIMENT CARRIER (U-9 & -10)	X			X		X	X	X	X						
SUBSAT FACILITY (S-9)	X			X		X	X	X	X						
SOC-SP OPS CTR (5 YR)				X^2	X^2	X^2	X^2	X^2	X^2						
LG SOLAR OBSERV (LEP)				X	X	X	X	X	X						
OPTIONAL SERVICE MISSIONS												X	X		X
1991 MISSIONS															
SPAS-01 STS PALLET SAT.	X			X		X	X	X	X						
25kW PWR MOD. (U-8)				X	X	X	X	X	X						
MAT'LS EXPERIMENT CARRIER (U-9 & -10)	X			X		X	X	X	X						
SUBSAT FACILITY (S-9)	X			X		X	X	X	X						
AXAF-ADV X-RAY ASTRO (A-9)				X	X	X	X	X	X						
CRO-COSMIC RAY OBSER (A-13)	X			X		X	X	X	X						
SOLAR TERR OBS (S-12)	X			X		X	X	X	X						
ADVANCED RELATIVITY (LEP)	X^2			X^2		X^2	X^2	X^2	X^2						
OPTIONAL SERVICE MISSIONS												X^2	X^2		X^2
1992 MISSIONS															
MAT'LS EXPERIMENT CARRIER (U-9 & -10)	X			X		X	X	X	X						
POLAIRE (LEP)	X			X		X	X	X	X						
SPS TEST ARTICLE (MDC) (U-13)				X^2	X^2	X^2	X^2	X^2	X^2						
AMBIENT DEPLOY. IR TELE (A-17)				X	X	X	X	X	X						
OPTIONAL SERVICE MISSIONS												X	X		X

R81-1108-071D-074D
1472-505(T)

NOTE: EXPONENT INDICATES NUMBER OF USES

FOLDOUT FRAME

FOLDOUT FRAME

B4 – INITIAL LAUNCH – EQUIPMENT UTILIZATION SUMMARY – DIRECT DELIVERY/SERVICING SATELLITE MISSIONS ('93)
HPA PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT											OPTIONAL EQUIPMENT			
1993 MISSIONS	RETENTION STRUCTURE	TILT TABLE	SPIN TABLE	RMS	PIDA	MFR/RMS	MMU/WRU		HPA	MTV	VSS	SUN SHIELD	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCE-MENT
							WITH END EFFECTOR	WITH STABILIZER							
SPAS-01 STS PALLET SAT.	X			X		X	X	X	X						
LDEF (01-10)	X			X		X	X	X	X						
25kW PWR MOD. (U-8)				X	X	X	X	X	X						
MAT'LS EXPERIMENT CARRIER (U-9 & -10)	X			X		X	X	X	X						
SPS TEST ARTICLE (MDC) (U-13)				X^2	X^2	X^2	X^2	X^2	X^2						
IR INTERFEROMETER (A-18)				X	X	X	X	X	X						
OPTIONAL SERVICE MISSIONS												X^2	X^2		X^2

R81-1108-075D
1472-506(T)

NOTE: EXPONENT INDICATES NUMBER OF USES

B5 – INITIAL LAUNCH – EQUIPMENT UTILIZATION SUMMARY – LEO/PROPULSION SATELLITE MISSIONS ('83 TO '86)
RMS PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT											OPTIONAL EQUIPMENT			
	RETENTION STRUCTURE	TILT TABLE	SPIN TABLE	RMS	PIDA	MFR/RMS	MMU/WRU		HPA	MTV	VSS	SUN SHIELD	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCEMENT
1983 MISSIONS							WITH END EFFECTOR	WITH STABILIZER							
LANDSAT D (R-2)	X	X		X		X	X	X^2		X					
CHEM REL MODULE (S-5)	X	X		X		X	X	X^2		X					
1984 MISSIONS															
ERBS – EARTH RAD BUDGET SAT. (E-4)	X	X		X		X	X	X^2		X					
LANDSAT D'' (5 YR)	X	X		X		X	X	X^2		X					
NOAA (E-5)	X	X		X		X	X	X^2		X					
OPTIONAL SERVICE MISSIONS												X	X	X	X
1985 MISSIONS															
CHEM REL MODULE (S-5)	X	X		X		X	X	X^2		X					
LANDSAT D''' (5 YR)	X	X		X		X	X	X^2		X					
COBE – COSMIC BKGND EXPL (GSF)	X	X		X		X	X	X^2		X					
GRAVSAT (R-4, GSF)	X^2	X^2		X^2		X^2	X^2	X^4		X^2					
STS – 46															
STS – 49															
OPTIONAL SERVICE MISSIONS												X	X	X	X
1986 MISSIONS	HPA PRIME USAGE														
NOAA (E-5)	X			X		X	X	X^2	X	X					
EUVE-EXTREME UV EXPLORER (A-5, GSF)	X			X		X	X	X^2	X	X					
REGION H20 QUAL MON (LEP)	X			X		X	X	X^2	X	X					
ORBITER CAMERA FR FLYER (MML)	X			X		X	X	X^2	X	X					
UARS-UPPER ATMOS RES (E-7)	X			X		X	X	X^2	X	X					
NOSS-NAT OCEAN SAT. (E-6)	X			X		X	X	X^2	X	X					
MAGSAT B (R-1)	X			X		X	X	X^2	X	X					
HI ENERGY EXPL (NAS)	X			X		X	X	X^2	X	X					
ASTROPHYSICS EXPL (GSF)	X			X		X	X	X^2	X	X					
X-RAY TIME EXPL (A-10, GSF)	X			X		X	X	X^2	X	X					
ICEX-ICE & CLIM EXP (5 YR)	X			X		X	X	X^2	X	X					
OP LAND OBSER SYS (LEP) (R-5)	X			X		X	X	X^2	X	X					
OPTIONAL SERVICE MISSIONS												X^2	X^2		X^2

R81-1108-054D-057D
1472-507(T)

NOTE: EXPONENT INDICATES NUMBER OF USES

B6 – INITIAL LAUNCH – EQUIPMENT UTILIZATION SUMMARY – LEO/PROPULSION SATELLITE MISSIONS ('87 TO '89)
HPA PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT											OPTIONAL EQUIPMENT			
	RETENTION STRUCTURE	TILT TABLE	SPIN TABLE	RMS	PIDA	MFR/RMS	MMU/WRU		HPA	MTV	VSS	SUN SHIELD	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCE-MENT
1987 MISSIONS							WITH END EFFECTOR	WITH STABILIZER							
ERBS – EARTH RAD BUDGET SAT. (E-4)	X			X		X	X	X^2	X	X	X				
NOAA (E-5)	X			X		X	X	X^2	X	X	X				
UARS-UPPER ATMOS RES (E-7)	X			X		X	X	X^2	X	X	X				
NOSS-NAT OCEAN SAT. (E-6)	X			X		X	X	X^2	X	X	X				
OP LAND OBSER SYS (LEP) (R-5)	X			X		X	X	X^2	X	X	X				
TOPEX-TOPOG EXP OCEAN CIRCULATION (E-9)	X			X		X	X	X^2	X	X	X				
SOIL MOISTURE (R-8)	X			X		X	X	X^2	X	X	X				
ALL WEATHER MICROWAVE (LEP)	X			X		X	X	X^2	X	X	X				
EARTH SURVEY (LEP)	X			X		X	X	X^2	X	X	X				
OPTIONAL SERVICE MISSIONS												X^2	X^2		X^2
1988 MISSIONS															
ORBITER CAMERA FR FLYER (MML)	X			X		X	X	X^2	X	X	X				
NOSS-NAT OCEAN SAT. (E-6)	X			X		X	X	X^2	X	X	X				
OP LAND OBSER SYS (LEP) (R-5)	X			X		X	X	X^2	X	X	X				
SCADM-SOLAR CYCLES & DYNAMICS MISS. (S-13)	X			X		X	X	X^2	X	X	X				
ADV GEOLOGY SAT. (LEP)	X			X		X	X	X^2	X	X	X				
GLOBAL REGIONAL ATHMOS MONITOR (LEP)	X			X		X	X	X^2	X	X	X				
LAMAR-LG AREA MOD. ARRAY (A-14, GSF)	X			X		X	X	X^2	X	X	X				
PRIV EARTH RES (LEP)	X			X		X	X	X^2	X	X	X				
ATMAS-ADV THERM MAP (R-6)	X			X		X	X	X^2	X	X	X				
VLBI-V, VLG BASE INT (A-15)	X			X		X	X	X^2	X	X	X				
OPTIONAL SERVICE MISSIONS												X^2	X^2		X^2
1989 MISSIONS															
NOSS-NAT OCEAN SAT. (E-6)	X			X		X	X	X^2	X	X	X				
X-RAY TIME EXPL (A-10, GSF)	X			X		X	X	X^2	X	X	X				
ICEX-ICE & CLIM EXP (5 YR)	X			X		X	X	X^2	X	X	X				
EARTH SURVEY (LEP)	X			X		X	X	X^2	X	X	X				
VLBI-V, LG BASE INT (A-15)	X			X		X	X	X^2	X	X	X				
GAMMA-RAY TRANSIENT EXPL (GSF)	X			X		X	X	X^2	X	X	X				
ENVIRON MONITOR (LEP)	X			X		X	X	X^2	X	X	X				
OP METEOROLOGY (E-10)	X			X		X	X	X^2	X	X	X				
ASTRONOMY (MDC)	X			X		X	X	X^2	X	X	X				
UV PHOTOMET/POLARIMET EXPL (GSF)	X			X		X	X	X^2	X	X	X				
X-RAY OBSERVATORY (GSF)	X			X		X	X	X^2	X	X	X				
OPTIONAL SERVICE MISSIONS												X^2	X^2		X^2

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NOTE: EXPONENT INDICATES NUMBER OF USES

FOLDOUT FRAME

FOLDOUT FRAME

B7 – INITIAL LAUNCH – EQUIPMENT UTILIZATION SUMMARY – LEO/PROPULSION SATELLITE MISSIONS ('90 TO '93)
HPA PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT											OPTIONAL EQUIPMENT			
	RETENTION STRUCTURE	TILT TABLE	SPIN TABLE	RMS	PIDA	MFR/RMS	MMU/WRU		HPA	MTV	VSS	SUN SHIELD	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCE-MENT
							WITH END EFFECTOR	WITH STABILIZER							
1990 MISSIONS															
GRAVSAT (R-4, GSF)	x^2			x^2		x^2	x^2	x^4	x^2	x^2	x^2				
OP LAND OBSER SYS (LEP) (R-5)	X			X		X	X	x^2	X	X	X				
SOIL MOISTURE (R-8)	X			X		X	X	x^2	X	X	X				
ATMAS-ADV THERM MAP (R-6)	X			X		X	X	x^2	X	X	X				
SOFT X-RAY SURVEY (GSF)	X			X		X	X	x^2	X	X	X				
MOLECULAR LINE SURVEY (GSF)	X			X		X	X	x^2	X	X	X				
X-RAY SPECTROSCOPY (GSF)	X			X		X	X	x^2	X	X	X				
OPTIONAL SERVICE MISSIONS												x^2	x^2		x^2
1991 MISSIONS															
ERBS – EARTH RAD BUDGET SAT. (E-4)	X			X		X	X	x^2	X	X	X				
OP LAND OBSER SYS (LEP) (R-5)	X			X		X	X	x^2	X	X	X				
SCADM-SOLAR CYCLES & DYNAMICS MISS. (S-13)	X			X		X	X	x^2	X	X	X				
EARTH SURVEY (LEP)	X			X		X	X	x^2	X	X	X				
ENVIRON MONITOR (LEP)	X			X		X	X	x^2	X	X	X				
OPTIONAL SERVICE MISSIONS												X	X		X
1992 MISSIONS															
NOSS-NAT OCEAN SAT. (E-6)	X			X		X	X	x^2	X	X	X				
OP LAND OBSER SYS (LEP) (R-5)	X			X		X	X	x^2	X	X	X				
ALL WEATHER MICROWAVE (LEP)	X			X		X	X	x^2	X	X	X				
GLOBAL REGIONAL ATHMOS MONITOR (LEP)	X			X		X	X	x^2	X	X	X				
PRIV EARTH RES (LEP)	X			X		X	X	x^2	X	X	X				
X-RAY OBSERVATORY (GSF)	X			X		X	X	x^2	X	X	X				
SUBMILLIMETER TELESCOPE (A-16)	X			X		X	X	x^2	X	X	X				
OPTIONAL SERVICE MISSIONS												x^2	x^2		x^2
1993 MISSIONS															
NOSS-NAT OCEAN SAT. (E-6)	X			X		X	X	x^2	X	X	X				
SOIL MOISTURE (R-8)	X			X		X	X	x^2	X	X	X				
EARTH SURVEY (LEP)	X			X		X	X	x^2	X	X	X				
ADV GEOLOGY SAT. (LEP)	X			X		X	X	x^2	X	X	X				
OPTIONAL SERVICE MISSIONS												X	X		X

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NOTE: EXPONENT INDICATES NUMBER OF USES

FOLDOUT FRAME

2 FOLDOUT FRAME

B8 – INITIAL LAUNCH – EQUIPMENT UTILIZATION SUMMARY – GEO SATELLITE MISSIONS ('83 TO '85)
RMS PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT											OPTIONAL EQUIPMENT			
	RETENTION STRUCTURE	TILT TABLE	SPIN TABLE	RMS	PIDA	MFR/RMS	MMU/WRU WITH END EFFECTOR	MMU/WRU WITH STABILIZER	HPA	MTV	VSS	SUN SHIELD	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCEMENT
1983 MISSIONS															
TDRS (C-1 & MDC)	X^2	X^2		X^2		X^2	X^2	X^2		X^2					
INTELSAT (AVN)	X	X	X	X		X	X	X		X					
TELESAT (AVN)	X		X	X		X	X	X		X					
SAT. BUS. SYS (MDC & AVN)	X		X	X		X	X	X		X					
RCA (AVN)	X		X	X		X	X	X		X					
INSAT (AVN & MDC)	X^2		X^2	X^2		X^2	X^2	X^2		X^2					
OPTIONAL SERVICE MISSIONS												X	X	X	X
													X	X	X
1984 MISSIONS															
TDRS (C-1 & MDC)	X	X		X		X	X	X		X					
INTELSAT (AVN)	X	X	X	X		X	X	X		X					
TELESAT (AVN)	X^2		X^2	X^2		X^2	X^2	X^2		X^2					
RCA (AVN)	X^2		X^2	X^2		X^2	X^2	X^2		X^2					
PALAPA (AVN)	X^2		X^2	X^2		X^2	X^2	X^2		X^2					
SYNCOM-IV (LEASAT, DoD)	X^3	X^3		X^3		X^3	X^3	X^3		X^3					
ARABSAT (AVN)	X^2		X^2	X^2		X^2	X^2	X^2		X^2					
AT&T (AVN)	X^2		X^2	X^2		X^2	X^2	X^2		X^2					
OPTIONAL SERVICE MISSIONS												X	X	X	X
													X	X	X
													X	X	X
1985 MISSIONS															
TDRS (C-1 & MDC)	X	X		X		X	X	X		X					
INTELSAT (AVN)	X	X	X	X		X	X	X		X					
TELESAT (AVN)	X		X	X		X	X	X		X					
SAT. BUS. SYS (MDC & AVN)	X		X	X		X	X	X		X					
RCA (AVN)	X		X	X		X	X	X		X					
SYNCOM-IV (LEASAT, DoD)	X^2	X^2		X^2		X^2	X^2	X^2		X^2					
AT&T(AVN)	X		X	X		X	X	X		X					
FOR. COMM/SBS (MDC)	X^2		X^2	X^2		X^2	X^2	X^2		X^2					
INMARSAT (MDC)	X		X	X		X	X	X		X					
GLOBAL DISASTER COMM (MDC)	X		X	X		X	X	X		X					
PEOP REP CHINA (AVN)	X		X	X		X	X	X		X					
OPTIONAL SERVICE MISSIONS													X	X	X
													X	X	X
													X	X	X

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NOTE: EXPONENT INDICATES NUMBER OF USES

FOLDOUT FRAME

2 FOLDOUT FRAME

B9 – INITIAL LAUNCH – EQUIPMENT UTILIZATION SUMMARY – GEO SATELLITE MISSIONS ('86, '87)
HPA PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT											OPTIONAL EQUIPMENT			
	RETENTION STRUCTURE	TILT TABLE	SPIN TABLE	RMS	PIDA	MFR/RMS	MMU/WRU		HPA	MTV	VSS	SUN SHIELD	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCEMENT
1986 MISSIONS							WITH END EFFECTOR	WITH STABILIZER							
INTELSAT (AVN)	X^2		X^2	X^2		X^2	X^2	X^2	X^2	X^2					
FOR. COMM/SBS (MDC)	X^4		X^4	X^4		X^4	X^4	X^4	X^4	X^4					
INMARSAT (MDC)	X^2		X^2	X^2		X^2	X^2	X^2	X^2	X^2					
PEOP REP CHINA (AVN)	X		X	X		X	X	X	X	X					
GOES-GEO ORB. ENV SAT. (E-2)	X		X	X		X	X	X	X	X					
30/20 GHz ANT. TRUNK (C-4)	X		X	X		X	X	X	X	X					
SEPS-SOL ELECT. PROP. (T-9)	X			X		X	X	X	X	X					
RESOURCES/POL'N/WEATH/COMM (MDC)	X		X	X		X	X	X	X	X					
FOREIGN COMM (MDC)	X		X	X		X	X	X	X	X					
EARTH OBS/COMMUN (MDC)	X		X	X		X	X	X	X	X					
OPTIONAL SERVICE MISSIONS												X	X		X
												X	X		X
												X	X		X
1987 MISSIONS															
INTELSAT (AVN)	X		X	X		X	X	X	X	X					
FOR. COMM/SBS (MDC)	X^2		X^2	X^2		X^2	X^2	X^2	X^2	X^2					
GOES-GEO ORB. ENV SAT. (E-2)	X		X	X		X	X	X	X	X					
STORMSAT (MDC)	X			X		X	X	X	X	X					
EARTH OBS/COMMUN (MDC)	X		X	X		X	X	X	X	X					
EARTH OBS/COMMUN (MDC)	X		X	X		X	X	X	X	X					
MAP GRAVITY FIELD/COMM (MDC)	X		X	X		X	X	X	X	X					
FOR. COMM/EARTH ORBS (MDC)	X		X	X		X	X	X	X	X					
INMETSAT (MDC)	X		X	X		X	X	X	X	X					
US/FOR. COMM (MDC)	X^2		X^2	X^2		X^2	X^2	X^2	X^2	X^2					
FOREIGN COMM (MDC)	X^3		X^3	X^3		X^3	X^3	X^3	X^3	X^3					
RESOURCES/POL'N/WEATH/COMM (MDC)	X		X	X		X	X	X	X	X					
NATO IV (MDC/DoD)	X			X	X	X	X	X	X	X					
OPTIONAL SERVICE MISSIONS												X	X		X
												X	X		X
												X	X		X

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NOTE: EXPONENT INDICATES NUMBER OF USES

FOLDOUT FRAME

FOLDOUT FRAME

B10 – INITIAL LAUNCH – EQUIPMENT UTILIZATION SUMMARY – GEO SATELLITE MISSIONS ('88, '89)
HPA PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT											OPTIONAL EQUIPMENT			
	RETENTION STRUCTURE	TILT TABLE	SPIN TABLE	RMS	PIDA	MFR/RMS	MMU/WRU		HPA	MTV	VSS	SUN SHIELD	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCE-MENT
1988 MISSIONS							WITH END EFFECTOR	WITH STABILIZER							
INTELSAT (AVN)	X^2		X^2	X^2		X^2	X^2	X^2	X^2	X^2					
FOR. COMM/SBS (MDC)	X^3		X^3	X^3		X^3	X^3	X^3	X^3	X^3					
30/20 GHz ANT. TRUNK (C-4)	X		X	X		X	X	X	X	X					
INMETSAT (MDC)	X^2		X^2	X^2		X^2	X^2	X^2	X^2	X^2					
FOREIGN COMM (MDC)	X^4		X^4	X^4		X^4	X^4	X^4	X^4	X^4					
RESOURCES/POL'N/WEATH/COMM (MDC)	X		X	X		X	X	X	X	X					
NATO IV (MDC/DoD)	X			X	X	X	X	X	X	X					
US COMM (MDC)	X^5		X^5	X^5		X^5	X^5	X^5	X^5	X^5					
THIN. ROUTE SYS COMM (C-6)	X			X		X	X	XQ	X	X					
RESOURCES/POL'N/WEATH/COMM (MDC)	X		X	X		X	X	X	X	X					
EARTH OBS/COMMUN (MDC)	X		X	X		X	X	X	X	X					
OPTIONAL SERVICE MISSIONS												X	X		X
												X	X		X
												X	X		X
												X	X		X
1989 MISSIONS															
INTELSAT (AVN)	X^2		X^2	X^2		X^2	X^2	X^2	X^2	X^2					
FOR. COMM/SBS (MDC)	X^2		X^2	X^2		X^2	X^2	X^2	X^2	X^2					
FOREIGN COMM (MDC)	X		X	X		X	X	X	X	X					
EARTH OBS/COMMUN (MDC)	X		X	X		X	X	X	X	X					
EARTH OBS/COMMUN (MDC)	X		X	X		X	X	X	X	X					
FOR. COMM/EARTH ORBS (MDC)	X		X	X		X	X	X	X	X					
INMETSAT (MDC)	X^4		X^4	X^4		X^4	X^4	X^4	X^4	X^4					
US/FOR. COMM (MDC)	X^2		X^2	X^2		X^2	X^2	X^2	X^2	X^2					
FOREIGN COMM (MDC)	X		X	X		X	X	X	X	X					
RESOURCES/POL'N/WEATH/COMM (MDC)	X^2		X^2	X^2		X^2	X^2	X^2	X^2	X^2					
NATO IV (MDC/DoD)	X			X	X	X	X	X	X	X					
US COMM (MDC)	X		X	X		X	X	X	X	X					
US COMM (MDC)	X		X	X		X	X	X	X	X					
ORBIT TRANS VEH (T-10)	X			X	X	X	X	X	X	X					
SIMUL ASTRON MISSION (G)	X			X		X	X	X	X	X					
INT UV-XPLOR-F/O (G)	X			X		X	X	X	X	X					
X-UV SPECTROSCOPY (G)	X			X		X	X	X	X	X					
OPTIONAL SERVICE MISSIONS												X^5	X^5		X^5

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NOTE: EXPONENT INDICATES NUMBER OF USES

FOLDOUT FRAME 1

2 FOLDOUT FRAME

B11 – INITIAL LAUNCH – EQUIPMENT UTILIZATION SUMMARY – GEO SATELLITE MISSIONS ('90, '91)
HPA PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT											OPTIONAL EQUIPMENT			
	RETENTION STRUCTURE	TILT TABLE	SPIN TABLE	RMS	PIDA	MFR/RMS	MMU/WRU		HPA	MTV	VSS	SUN SHIELD	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCE-MENT
1990 MISSIONS							WITH END EFFECTOR	WITH STABILIZER							
INTELSAT (AVN)	X^2		X^2	X^2		X^2	X^2	X^2	X^2	X^2					
FOR. COMM/SBS (MDC)	X^5		X^5	X^5		X^5	X^5	X^5	X^5	X^5					
INMARSAT (MDC)	X^2		X^2	X^2		X^2	X^2	X^2	X^2	X^2					
RESOURCES/POL'N/WEATH/COMM (MDC)	X		X	X		X	X	X	X	X					
EARTH OBS/COMMUN (MDC)	X		X	X		X	X	X	X	X					
INMETSAT (MDC)	X^3		X^3	X^3		X^3	X^3	X^3	X^3	X^3					
US/FOR. COMM (MDC)	X		X	X		X	X	X	X	X					
FOREIGN COMM (MDC)	X^2		X^2	X^2		X^2	X^2	X^2	X^2	X^2					
US COMM (MDC)	X^3		X^3	X^3		X^3	X^3	X^3	X^3	X^3					
RESOURCES/POL'N/WEATH/COMM (MDC)	X		X	X		X	X	X	X	X					
US COMM (MDC)	X		X	X		X	X	X	X	X					
US COMM (MDC)	X		X	X		X	X	X	X	X					
ORBIT TRANS VEH (T-10)	X^2			X^2	X^2	X^2	X^2	X^2	X^2	X^2					
OPTIONAL SERVICE MISSIONS												X^5	X^5		X^5
FOREIGN COMM (MDC)	X		X	X		X	X	X	X	X					
1991 MISSIONS															
FOR. COMM/SBS (MDC)	X^5		X^5	X^5		X^5	X^5	X^5	X^5	X^5					
RESOURCES/POL'N/WEATH/COMM (MDC)	X		X	X		X	X	X	X	X					
MAP GRAVITY FIELD/COMM (MDC)	X		X	X		X	X	X	X	X					
FOR. COMM/EARTH ORBS (MDC)	X		X	X		X	X	X	X	X					
INMETSAT (MDC)	X^4		X^4	X^4		X^4	X^4	X^4	X^4	X^4					
US/FOR. COMM (MDC)	X		X	X		X	X	X	X	X					
FOREIGN COMM (MDC)	X		X	X		X	X	X	X	X					
RESOURCES/POL'N/WEATH/COMM (MDC)	X^2		X^2	X^2		X^2	X^2	X^2	X^2	X^2					
ORBIT TRANS VEH (T-10)	X^2			X^2	X^2	X^2	X^2	X^2	X^2	X^2					
OPTIONAL SERVICE MISSIONS												X^4	X^4		X^4
FOREIGN COMM/EARTH OBS (MDC)	X^2		X^2	X^2		X^2	X^2	X^2	X^2	X^2					
ELECTRONIC MAIL (MDC)	X			X		X	X	X	X	X					

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NOTE: EXPONENT INDICATES NUMBER OF USES

FOLDOUT FRAME

2 FOLDOUT FRAME

B12 – INITIAL LAUNCH – EQUIPMENT UTILIZATION SUMMARY – GEO SATELLITE MISSIONS ('92, '93)
HPA PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT											OPTIONAL EQUIPMENT			
	RETENTION STRUCTURE	TILT TABLE	SPIN TABLE	RMS	PIDA	MFR/RMS	MMU/WRU		HPA	MTV	VSS	SUN SHIELD	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCE-MENT
1992 MISSIONS							WITH END EFFECTOR	WITH STABILIZER							
TDRS (C-1 & MDC)	X			X		X	X	X	X	X					
TELESAT (AVN)	X		X	X		X	X	X	X	X					
SAT. BUS. SYS (MDC & AVN)	X		X	X		X	X	X	X	X					
FOR. COMM/SBS (MDC)	X^2		X^2	X^2		X^2	X^2	X^2	X^2	X^2					
GLOBAL DISASTER COMM (MDC)	X		X	X		X	X	X	X	X					
GOES-GEO ORB. ENV SAT. (E-2)	X		X	X		X	X	X	X	X					
STORMSAT (MDC)	X			X		X	X	X	X	X					
EARTH OBS/COMMUN (MDC)	X		X	X		X	XQ	X	X	X					
INMETSAT (MDC)	X^2		X^2	X^2		X^2	X^2	X^2	X^2	X^2					
FOREIGN COMM (MDC)	X		X	X		X	X	X	X	X					
ORBIT TRANS VEH (T-10)	X^3			X^3	X^3	X^3	X^3	X^3	X^3	X^3					
OPTIONAL SERVICE MISSIONS												X^4	X^4		X^4
FOREIGN COMM/EARTH OBS (MDC)	X^2		X^2	X^2		X^2	X^2	X^2	X^2	X^2					
PERSONAL COMM DEMO (MDC)	X^2			X^2	X^2	X^2	X^2	X^2	X^2	X^2					
PUBLIC BROADCAST (MDC)	X			X		X	X	X	X	X					
MANNED GEO SORTIE (T-12)	X			X	X	X	X	X	X	X					
1993 MISSIONS															
FOR. COMM/SBS (MDC)	X^4		X^4	X^4		X^4	X^4	X^4	X^4	X^4					
FOREIGN COMM (MDC)	X		X	X		X	X	X	X	X					
EARTH OBS/COMMUN (MDC)	X		X	X		X	X	X	X	X					
EARTH OBS/COMMUN (MDC)	X		X	X		X	X	X	X	X					
FOR. COMM/EARTH ORBS (MDC)	X		X	X		X	X	X	X	X					
INMETSAT (MDC)	X^4		X^4	X^4		X^4	X^4	X^4	X^4	X^4					
US/FOR. COMM (MDC)	X		X	X		X	X	X	X	X					
FOREIGN COMM (MDC)	X^2		X^2	X^2		X^2	X^2	X^2	X^2	X^2					
RESOURCES/POL'N/WEATH/COMM (MDC)	X^2		X^2	X^2		X^2	X^2	X^2	X^2	X^2					
US COMM (MDC)	X^2		X^2	X^2		X^2	X^2	X^2	X^2	X^2					
RESOURCES/POL'N/WEATH/COMM (MDC)	X		X	X		X	X	X	X	X					
ORBIT TRANS VEH (T-10)	X^6			X^6	X^6	X^6	X^6	X^6	X^6	X^6					
OPTIONAL SERVICE MISSIONS												X^6	X^6		X^6
FOREIGN COMM/EARTH OBS (MDC)	X^2		X^2	X^2		X^2	X^2	X^2	X^2	X^2					
MANNED GEO SORTIE (T-12)	X^2			X^2	X^2	X^2	X^2	X^2	X^2	X^2					
EDUCATIONAL TV (MDC)	X			X	X	X	X	X	X	X					

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NOTE: EXPONENT INDICATES NUMBER OF USES

FOLDOUT FRAME

FOLDOUT FRAME

B13 – INITIAL LAUNCH – EQUIPMENT UTILIZATION SUMMARY – PLANETARY/OTHER MISSIONS ('84, '85)
RMS PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT											OPTIONAL EQUIPMENT			
1984 MISSIONS	RETENTION STRUCTURE	TILT TABLE	SPIN TABLE	RMS	PIDA	MFR/RMS	MMU/WRU		HPA	MTV	VSS	SUN SHIELD	ORBITAL STORAGE	ATTITUDW TRANSFER PACKAGE	LIGHT ENHANCE-MENT
							WITH END EFFECTOR	WITH STABILIZER							
PLANETARY															
GALILEO ORBITER (P-1)	X			X	X	X	X	X		X					
GALILEO PROBE (P-1)	X			X	X	X	X	X		X					
AMPTE-ALT MAG PART EXPT (S-6)	X			X	X	X	X	X		X					
OPTIONAL SERVICE MISSIONS												X	X	X	X
1985 MISSIONS															
PLANETARY															
HALLEY FLYBY (P-3, 5 YR)	X			X	X	X	X	X		X					
INT SOLAR POLAR MISS. (A-3, S-3, FAM)	X^2			X^2	X^2	X^2	X^2	X^2		X^2					
OPTIONAL SERVICE MISSIONS												X	X	X	X

R81-1108-098D-099D
1472-515(T)

NOTE: EXPONENT INDICATES NUMBER OF USES

FOLDOUT FRAME

2 FOLDOUT FRAME

B14 – INITIAL LAUNCH – EQUIPMENT UTILIZATION SUMMARY – PLANETARY/OTHER MISSIONS ('86 TO '93)
HPA PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT											OPTIONAL EQUIPMENT			
	RETENTION STRUCTURE	TILT TABLE	SPIN TABLE	RMS	PIDA	MFR/RMS	MMU/WRU		HPA	MTV	VSS	SUN SHIELD	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCE-MENT
1986 MISSIONS							WITH END EFFECTOR	WITH STABILIZER							
PLANETARY															
VENUS ORBIT IMG RAD (P-2)	X			X	X	X	X	X	X	X					
ORIGIN OF PLASMA	X^4			X^4	X^4	X^4	X^4	X^4	X^4	X^4					
COMET RENDEZ (P-3, 5 YR)	X			X	X	X	X	X	X	X					
OPTIONAL SERVICE MISSIONS												X	X		X
1987 MISSIONS															
PLANETARY															
PLASMA TURB EXPLOR	X			X	X	X	X	X	X	X					
1988 MISSIONS															
PLANETARY															
SOLAR PROBE (S-11)	X			X	X	X	X	X	X	X					
1989 MISSIONS															
PLANETARY															
ADV INTERPLAN EXPLORER (G)	X			X	X	X	X	X	X	X					
SATURN ORBIT (DUAL) (P-4)	X			X	X	X	X	X	X	X					
OPTIONAL SERVICE MISSIONS												X	X		X
1991 MISSIONS															
UNP PROG-URAN NEP PLUTO (P-6)	X			X	X	X	X	X	X	X					
1992 MISSIONS															
PLANETARY															
UNP PROG-URAN NEP PLUTO (P-6)	X			X	X	X	X	X	X	X					
1993 MISSIONS															
PLANETARY															
LUNAR POLAR ORBIT (P-8)	X			X	X	X	X	X	X	X					
NR EARTH ASTEROID SAMPLE (P-11)	X			X	X	X	X	X	X	X					
ASTEROID MULT RENDEZ (P-7)	X			X	X	X	X	X	X	X					
EXTRATERRESTRIAL MAT'L PROC (U-3)	X			X	X	X	X	X	X	X					
OPTIONAL SERVICE MISSIONS												X	X		X

R81-1108-100D-106D
1472-516(T)

NOTE: EXPONENT INDICATES NUMBER OF USES

FOLDOUT FRAME 1

2 FOLDOUT FRAME

B15 – INITIAL LAUNCH – EQUIPMENT UTILIZATION SUMMARY – SORTIE MISSIONS ('83 TO '85)
RMS PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT											OPTIONAL EQUIPMENT			
	RETENTION STRUCTURE	TILT TABLE	SPIN TABLE	RMS	PIDA	MFR/RMS	MMU/WRU		HPA	MTV	VSS	SUN SHIELD	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCEMENT
1983 MISSIONS							WITH END EFFECTOR	WITH STABILIZER							
OSTA (SPACE & TERRESTRIAL APPLICATIONS)				X		X	X	X							
SPACELAB-1 (VERIF & MULTIDISCIPLINE)				X		X	X	X							
TETHERED SATELLITE SYSTEM (U-4)				X		X	X	X							
SPACELAB (SOLAR & ASTRO PHYSICS)				X		X	X	X							
MPS (MATERIAL PROCESSING) (U-1)				X		X	X	X							
1984 MISSIONS															
OSTA (SPACE & TERRESTRIAL APPLICATIONS)				X^2		X^2	X^2	X^2							
SPAS-01				X		X	X	X							
TETHERED SATELLITE SYSTEM (U-4)				X		X	X	X							
MPS (MATERIAL PROCESSING) (U-1)				X^2		X^2	X^2	X^2							
PEP-PWR EXT PKG				X^2		X^2	X^2	X^2							
SPACELAB-3 (LOW GRAVITY)				X		X	X	X							
SPACELAB (LIFE SCIENCES) (L-1)				X		X	X	X							
OSS (SPACE SCIENCES)				X		X	X	X							
SPACELAB (BMFT)				X		X	X	X							
SPACELAB (SOLAR TERR)				X		X	X	X							
1985 MISSIONS															
OSTA (SPACE & TERRESTRIAL APPLICATIONS)				X^2		X^2	X^2	X^2							
TETHERED SATELLITE SYSTEM (U-4)				X		X	X	X							
SPACELAB (SOLAR & ASTRO PHYSICS)				X		X	X	X							
MPS (MATERIAL PROCESSING) (U-1)				X		X	X	X							
PEP-PWR EXT PKG				X^4		X^4	X^4	X^4							
SPACELAB (LIFE SCIENCES) (L-1)				X		X	X	X							
OSS (SPACE SCIENCES)				X^2		X^2	X^2	X^2							
SPACELAB (BMFT)				X		X	X	X							
LARGE DEPLOY. ANTENNA (GAC)				X		X	X	X							
SPACELAB (EARTH OBS)				X		X	X	X							
SPACELAB (MATL PROC)				X		X	X	X							

R81-1108-076D-078D
1472-517(T)

NOTE: EXPONENT INDICATES NUMBER OF USES

FOLDOUT FRAME 1

2 FOLDOUT FRAME

B16 – INITIAL LAUNCH – EQUIPMENT UTILIZATION SUMMARY – SORTIE MISSIONS ('86 TO '88)
RMS PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT											OPTIONAL EQUIPMENT			
	RETENTION STRUCTURE	TILT TABLE	SPIN TABLE	RMS	PIDA	MFR/RMS	MMU/WRU		HPA	MTV	VSS	SUN SHIELD	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCEMENT
1986 MISSIONS							WITH END EFFECTOR	WITH STABILIZER							
OSTA (SPACE & TERRESTRIAL APPLICATIONS)				x^2		x^2	x^2	x^2							
SPAS-01				x		x	x	x							
TETHERED SATELLITE SYSTEM (U-4)				x		x	x	x							
SPACELAB (SOLAR & ASTRO PHYSICS)				x^2		x^2	x^2	x^2							
MPS (MATERIAL PROCESSING) (U-1)				x		x	x	x							
PEP-PWR EXT PKG				x^6		x^6	x^6	x^6							
SPACELAB (LIFE SCIENCES) (L-1)				x		x	x	x							
OSS (SPACE SCIENCES)				x^2		x^2	x^2	x^2							
SPACELAB (BMFT)				x		x	x	x							
SPACELAB (SOLAR TERR)				x		x	x	x							
SPACELAB (MATL PROC)				x		x	x	x							
SPACELAB-11 PLASMA				x		x	x	x							
SIRT-IR TELE FAC (A-6) (2 PALLET)				x		x	x	x							
1987 MISSIONS															
OSTA (SPACE & TERRESTRIAL APPLICATIONS)				x^2		x^2	x^2	x^2							
TETHERED SATELLITE SYSTEM (U-4)				x		x	x	x							
SPACELAB (SOLAR & ASTRO PHYSICS)				x		x	x	x							
MPS (MATERIAL PROCESSING) (U-1)				x		x	x	x							
PEP-PWR EXT PKG				x^7		x^7	x^7	x^7							
OSS (SPACE SCIENCES)				x^2		x^2	x^2	x^2							
SPACELAB (BMFT)				x		x	x	x							
SPACELAB (EARTH OBS)				x		x	x	x							
SPACELAB (MATL PROC)				x		x	x	x							
STARLAB TELESCOPE (A-11, G) (2 PALLET)				x		x	x	x							
SOLAR SOFT X-RAYS (S-8) (1 PALLET)				x		x	x	x							
1988 MISSIONS															
OSTA (SPACE & TERRESTRIAL APPLICATIONS)				x^2		x^2	x^2	x^2							
SPAS-01				x		x	x	x							
SPACELAB (SOLAR & ASTRO PHYSICS)				x		x	x	x							
MPS (MATERIAL PROCESSING) (U-1)				x		x	x	x							
PEP-PWR EXT PKG				x^8		x^8	x^8	x^8							
SPACELAB (LIFE SCIENCES) (L-1)				x		x	x	x							
OSS (SPACE SCIENCES)				x^2		x^2	x^2	x^2							
SPACELAB (BMFT)				x		x	x	x							
SPACELAB (SOLAR TERR)				x		x	x	x							
SPACELAB (MATL PROC)				x		x	x	x							
SPACELAB-PIN HOLE (S-14) (1 PALLET)				x		x	x	x							
LIDAR (ET-47) (1 PALLET)				x		x	x	x							

R81-1108-079D-081D
1472-518(T)

NOTE: EXPONENT INDICATES NUMBER OF USES

FOLDOUT FRAME

FOLDOUT FRAME

B17 – INITIAL LAUNCH – EQUIPMENT UTILIZATION SUMMARY – SORTIE MISSIONS ('89 TO '91)
RMS PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT											OPTIONAL EQUIPMENT			
	RETENTION STRUCTURE	TILT TABLE	SPIN TABLE	RMS	PIDA	MFR/RMS	MMU/WRU		HPA	MTV	VSS	SUN SHIELD	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCE-MENT
1989 MISSIONS							WITH END EFFECTOR	WITH STABILIZER							
OSTA (SPACE & TERRESTRIAL APPLICATIONS)				x^2		x^2	x^2	x^2							
SPACELAB (SOLAR & ASTRO PHYSICS)				x		x	x	x							
MPS (MATERIAL PROCESSING) (U-1)				x		x	x	x							
PEP-PWR EXT PKG				x^8		x^8	x^8	x^8							
SPACELAB (LIFE SCIENCES) (L-1)				x		x	x	x							
OSS (SPACE SCIENCES)				x^2		x^2	x^2	x^2							
SPACELAB (BMFT)				x		x	x	x							
SPACELAB (EARTH OBS)				x		x	x	x							
SPACELAB (MATL PROC)				x		x	x	x							
1990 MISSIONS															
OSTA (SPACE & TERRESTRIAL APPLICATIONS)				x^2		x^2	x^2	x^2							
SPAS-01				x		x	x	x							
SPACELAB (SOLAR & ASTRO PHYSICS)				x		x	x	x							
MPS (MATERIAL PROCESSING) (U-1)				x		x	x	x							
PEP-PWR EXT PKG				x^8		x^8	x^8	x^8							
OSS (SPACE SCIENCES)				x^2		x^2	x^2	x^2							
SPACELAB (BMFT)				x		x	x	x							
SPACELAB (SOLAR TERR)				x		x	x	x							
SPACELAB (MATL PROC)				x		x	x	x							
1991 MISSIONS															
OSTA (SPACE & TERRESTRIAL APPLICATIONS)				x^2		x^2	x^2	x^2							
SPACELAB (SOLAR & ASTRO PHYSICS)				x		x	x	x							
MPS (MATERIAL PROCESSING) (U-1)				x		x	x	x							
PEP-PWR EXT PKG				x^8		x^8	x^8	x^8							
SPACELAB (LIFE SCIENCES) (L-1)				x		x	x	x							
OSS (SPACE SCIENCES)				x^2		x^2	x^2	x^2							
SPACELAB (BMFT)				x		x	x	x							
SPACELAB (EARTH OBS)				x		x	x	x							
SPACELAB (MATL PROC)				x		x	x	x							

R81-1108-082D-084D
1472-519(T)

NOTE: EXPONENT INDICATES NUMBER OF USES

FOLDOUT FRAME 1

2 FOLDOUT FRAME

C-2

B18 – INITIAL LAUNCH – EQUIPMENT UTILIZATION SUMMARY – SORTIE MISSIONS ('92, '93)
RMS PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT											OPTIONAL EQUIPMENT			
	RETENTION STRUCTURE	TILT TABLE	SPIN TABLE	RMS	PIDA	MFR/RMS	MMU/WRU		HPA	MTV	VSS	SUN SHIELD	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCE-MENT
							WITH END EFFECTOR	WITH STABILIZER							
1992 MISSIONS															
OSTA (SPACE & TERRESTRIAL APPLICATIONS)				X^2		X^2	X^2	X^2							
SPAS-01				X		X	X	X							
SPACELAB (SOLAR & ASTRO PHYSICS)				X		X	X	X							
MPS (MATERIAL PROCESSING) (U-1)				X		X	X	X							
PEP-PWR EXT PKG				X^8		X^8	X^8	X^8							
SPACELAB (LIFE SCIENCES) (L-1)				X		X	X	X							
OSS (SPACE SCIENCES)				X^2		X^2	X^2	X^2							
SPACELAB (BMFT)				X		X	X	X							
SPACELAB (SOLAR TERR)				X		X	X	X							
SPACELAB (MATL PROC)				X		X	X	X							
1993 MISSIONS															
OSTA (SPACE & TERRESTRIAL APPLICATIONS)				X^2		X^2	X^2	X^2							
SPACELAB (SOLAR & ASTRO PHYSICS)				X		X	X	X							
MPS (MATERIAL PROCESSING) (U-1)				X		X	X	X							
PEP-PWR EXT PKG				X^8		X^8	X^8	X^8							
OSS (SPACE SCIENCES)				X^2		X^2	X^2	X^2							
SPACELAB (BMFT)				X		X	X	X							
SPACELAB (EARTH OBS)				X		X	X	X							
SPACELAB (MATL PEP-PO)				X		X	X	X							

R81-1108-085D-086D
1472-520(T)

NOTE: EXPONENT INDICATES NUMBER OF USES

B19 – INITIAL LAUNCH – EQUIPMENT UTILIZATION SUMMARY – DoD MISSIONS ('83 TO '85)
RMS PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT											OPTIONAL EQUIPMENT			
	RETENTION STRUCTURE	TILT TABLE	SPIN TABLE	RMS	PIDA	MFR/RMS	MMU/WRU WITH END EFFECTOR	MMU/WRU WITH STABILIZER	HPA	MTV	VSS	SUN SHIELD	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCE-MENT
1983 MISSIONS															
DoD 83-1				X		X	X	X							
DoD 83-2				X		X	X	X							
DoD 84-1				X		X	X	X							
P80-1-STP	X	X		X		X	X	X		X					
SPACE IR EXPERIMENT (SIRE)	X	X		X		X	X	X		X					
1984 MISSIONS															
DoD 84-2				X		X	X	X							
DoD 85-1				X		X	X	X							
DoD 85-2				X		X	X	X							
SPACE IR EXPERIMENT (SIRE)	X	X		X		X	X	X		X					
GLOBAL POSITIONING SAT.	X	X	X	X		X	X	X		X					
TRANSIT	X	X		X		X	X	X		X					
OPTIONAL SERVICE MISSIONS												X	X	X	X
1985 MISSIONS															
DoD 85-3				X		X	X	X							
DoD 85-4				X		X	X	X							
DoD 85-5				X		X	X	X							
DoD 85-6				X		X	X	X							
DoD 85-7				X		X	X	X							
DoD 85-8				X		X	X	X							
DoD 86-1				X		X	X	X							
GLOBAL POSITIONING SAT.	X^4	X^4	X^4	X^4		X^4	X^4	X^4		X^4					
TRANSIT	X	X		X		X	X	X		X					
DEFENSE SAT. COMM SYSTEM	X^2	X^2		X^2		X^2	X^2	X^2		X^2					
SPACE IR EXP	X	X		X		X	X	X		X					
OPTIONAL SERVICE MISSIONS												X^2	X^2	X^2	X^2

R81-1108-087D-089D
1472-521(T)

NOTE: EXPONENT INDICATES NUMBER OF USES

FOLDOUT FRAME

2 FOLDOUT FRAME

B20 – INITIAL LAUNCH – EQUIPMENT UTILIZATION SUMMARY – DoD MISSIONS ('86, '87)
HPA PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT											OPTIONAL EQUIPMENT			
	RETENTION STRUCTURE	TILT TABLE	SPIN TABLE	RMS	PIDA	MFR/RMS	MMU/WRU		HPA	MTV	VSS	SUN SHIELD	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCEMENT
1986 MISSIONS							WITH END EFFECTOR	WITH STABILIZER							
DoD 86-2				X		X	X	X							
DoD 86-3				X		X	X	X							
DoD 86-6				X		X	X	X							
DoD 86-8				X		X	X	X							
DoD 86-10				X		X	X	X							
DoD 86-11				X		X	X	X							
GLOBAL POSITIONING SAT.	X^6		X^6	X^6		X^6	X^6	X^6	X^6	X^6					
TRANSIT	X			X		X	X	X	X	X					
DEFENSE SAT. COMM SYSTEM (1)	X^2			X^2		X^2	X^2	X^2	X^2	X^2					
SPACE TEST PROGRAM (STP)	X			X		X	X	X	X	X					
TALON GOLD-STP	X			X		X	X	X	X						
OPTIONAL SERVICE MISSIONS												X^2	X^2		X^2
1987 MISSIONS															
GLOBAL POSITIONING SAT.	X^7		X^7	X^7		X^7	X^7	X^7	X^7	X^7					
TRANSIT	X			X		X	X	X	X	X					
DEFENSE SAT. COMM SYSTEM	X^2			X^2		X^2	X^2	X^2	X^2	X^2					
SPACE TEST PROGRAM (STP)	X			X		X	X	X	X	X					
DEFENSE MET. SAT. PGM (DMSP)	X			X		X	X	X	X						
OPTIONAL SERVICE MISSIONS												X^2	X^2		X^2

R81-1108-090D-091D
1472-522(T)

NOTE: EXPONENT INDICATES NUMBER OF USES

FOLDOUT FRAME 1

2 FOLDOUT FRAME

B21 – INITIAL LAUNCH – EQUIPMENT UTILIZATION SUMMARY – DoD MISSIONS ('88)
HPA PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT											OPTIONAL EQUIPMENT			
1988 MISSIONS	RETENTION STRUCTURE	TILT TABLE	SPIN TABLE	RMS	PIDA	MFR/RMS	MMU/WRU WITH END EFFECTOR	MMU/WRU WITH STABILIZER	HPA	MTV	VSS	SUN SHIELD	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCE-MENT
GLOBAL POSITIONING SAT.	x^7		x^7	x^7		x^7	x^7	x^7	x^7	x^7					
TRANSIT	X			X		X	X	X	X	X					
SPACE TEST PROGRAM (STP)	X			X		X	X	X	X	X					
DEFENSE MET. SAT. PGM (DMSP)	X			X		X	X	X	X						
MINI HALO-STP	X			X		X	X	X	X	X					
OPTIONAL SERVICE MISSIONS												x^2	x^2		x^2

R81-1108-092D
1472-523(T)

NOTE: EXPONENT INDICATES NUMBER OF USES

FOLDOUT FRAME

2 FOLDOUT FRAME

B22 – INITIAL LAUNCH – EQUIPMENT UTILIZATION SUMMARY – DoD MISSIONS ('89 TO '93)
HPA PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT											OPTIONAL EQUIPMENT			
	RETENTION STRUCTURE	TILT TABLE	SPIN TABLE	RMS	PIDA	MFR/RMS	MMU/WRU		HPA	MTV	VSS	SUN SHIELD	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCE-MENT
							WITH END EFFECTOR	WITH STABILIZER							
1989 MISSIONS															
GLOBAL POSITIONING SAT.	x^2		x^2	x^2		x^2	x^2	x^2	x^2	x^2					
TRANSIT	X			X		X	X	X	X	X					
DEFENSE SAT. COMM SYSTEM	x^2			x^2		x^2	x^2	x^2	x^2	x^2					
SPACE TEST PROGRAM (STP)	X			X		X	X	X	X	X					
DEFENSE MET. SAT. PGM (DMSP)	X			X		X	X	X	X						
OPTIONAL SERVICE MISSIONS												x^2	x^2		x^2
1990 MISSIONS															
GLOBAL POSITIONING SAT.	x^4		x^4	x^4		x^4	x^4	x^4	x^4	x^4					
TRANSIT	X			X		X	X	X	X	X					
SPACE TEST PROGRAM (STP)	X			X		X	X	X	X	X					
DEFENSE MET. SAT. PGM (DMSP)	X			X		X	X	X	X						
OPTIONAL SERVICE MISSIONS												x^2	x^2		x^2
1991 MISSIONS															
GLOBAL POSITIONING SAT.	x^2		x^2	x^2		x^2	x^2	x^2	x^2	x^2					
TRANSIT	X			X		X	X	X	X	X					
DEFENSE SAT. COMM SYSTEM	x^2			x^2		x^2	x^2	x^2	x^2	x^2					
SPACE TEST PROGRAM (STP)	X			X		X	X	X	X	X					
DEFENSE MET. SAT. PGM (DMSP)	X			X		X	X	X	X						
OPTIONAL SERVICE MISSIONS												X	X		X
1992 MISSIONS															
GLOBAL POSITIONING SAT.	x^4		x^4	x^4		x^4	x^4	x^4	x^4	x^4					
DEFENSE SAT. COMM SYSTEM	x^2			x^2		x^2	x^2	x^2	x^2	x^2					
SPACE TEST PROGRAM (STP)	X			X		X	X	X	X	X					
DEFENSE MET. SAT. PGM (DMSP)	X			X		X	X	X	X						
OPTIONAL SERVICE MISSIONS												x^2	x^2		x^2
1993 MISSIONS															
GLOBAL POSITIONING SAT.	x^2		x^2	x^2		x^2	x^2	x^2	x^2	x^2					
SPACE TEST PROGRAM (STP)	X			X		X	X	X	X	X					
DEFENSE MET. SAT. PGM (DMSP)	X			X		X	X	X	X						
OPTIONAL SERVICE MISSIONS												X	X		X

R81-1108-093D-097D
1472-524(T)

NOTE: EXPONENT INDICATES NUMBER OF USES

FOLDOUT FRAME

FOLDOUT FRAME

B23 – REVISIT – EQUIPMENT UTILIZATION SUMMARY – DIRECT DELIVERY/SERVICING SATELLITE MISSIONS ('85 TO '89)
TILT TABLE PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT															OPTIONAL EQUIPMENT		
	EQUIPMENT STOWAGE PROVISIONS	FLUID TRANSFER SYSTEM	TILT TABLE		OCP		MMU/WRU				HPA	NONCONT ACS	MTV POM	MTV	VSS	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCEMENT
1985 MISSIONS				RMS	WK PLAT FOR TILT TABLE	OCP/RMS	POM	WITH END EFFECTOR	WITH STABILIZER	WITH PAY-LOAD HDLG								
SPACE TELESCOPE (A-3)	X	X	X	X	X	X		X	X^2	X		X	X	X				
1986 MISSIONS	HPA PRIME USAGE																	
SPACE TELESCOPE (A-3)	X	X		X		X		X	X	X	X	X	X	X				
GRO-GAMMA RAY OBSER (A-7)	X	X		X		X		X	X	X	X		X	X				
OPTIONAL SERVICE MISSIONS																X		X
1987 MISSIONS																		
SPACE TELESCOPE (A-3)	X	X		X		X		X	X	X	X	X	X	X				
LDEF (01-10)	X	X		X		X	X	X	X	X	X	X		X				
SASP-SCI & APP SP PLAT (U-7 & L-2)	X	X		X		X		X	X	X	X			X				
25kW PWR MOD. (U-8)	X	X		X		X		X	X	X	X			X				
OPTIONAL SERVICE MISSIONS																X		X
1988 MISSIONS																		
SPACE TELESCOPE (A-3)	X	X		X		X		X	X	X	X	X	X	X				
SASP-SCI & APP SP PLAT (U-7 & L-2)	X	X		X		X		X	X	X	X			X				
25kW PWR MOD. (U 8)	X	X		X		X		X	X	X	X			X				
AXAF-ADV X-RAY ASTRO (A-9)	X	X		X		X		X	X	X	X	X	X	X				
CRO-COSMIC RAY OBSER (A-13)	X	X		X		X		X	X	X	X		X	X				
GRAVITY PROBE B (A-8)	X	X		X		X		X	X	X	X		X	X				
COASTAL SAT. (NAS)	X	X		X		X	X	X	X	X	X			X				
OPTIONAL SERVICE MISSIONS																X		X
1989 MISSIONS																		
SASP-SCI & APP SP PLAT (U-7 & L-2)	X^2	X^2		X^2		X^2		X^2	X^2	X^2	X^2			X^2				
25kW PWR MOD. (U-8)	X^2	X^2		X^2		X^2		X^2	X^2	X^2	X^2			X^2				
MAG FIELD SURV B (R-7)	X	X		X		X	X	X	X	X	X			X				
AXAF-ADV X-RAY ASTRO (A-9)	X	X		X		X		X	X	X	X	X	X	X				
CRO-COSMIC RAY OBSER (A-13)	X	X		X		X		X	X	X	X		X	X				
GRAVITY PROBE B (A-8)	X	X		X		X		X	X	X	X		X	X				
COASTAL SAT. (NAS)	X	X		X		X	X	X	X	X	X			X				
OPTIONAL SERVICE MISSIONS																X^2		X^2

R81-1108-126D-130D
1472-525(T)

NOTE: EXPONENT INDICATES NUMBER OF USES

B24 – REVISIT – EQUIPMENT UTILIZATION SUMMARY – DIRECT DELIVERY/SERVICING SATELLITE MISSIONS ('90 TO '92)
HPA PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT															OPTIONAL EQUIPMENT		
	EQUIPMENT STOWAGE PROVISIONS	FLUID TRANSFER SYSTEM	TILT TABLE	RMS	OCP		MMU/WRU				HPA	NONCONT ACS	MTV POM	MTV	VSS	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCEMENT
1990 MISSIONS					WK PLAT FOR TILT TABLE	OCP/RMS	POM	WITH END EFFECTOR	WITH STABILIZER	WITH PAY-LOAD HDLG								
LDEF (01-10)	X	X		X		X	X	X	X	X	X	X		X				
SASP-SCI & APP SP PLAT (U-7 & L-2)	X^2	X^2		X^2		X^2		X^2	X^2	X^2	X^2			X^2				
25kW PWR MOD. (U-8)	X^2	X^2		X^2		X^2		X^2	X^2	X^2	X^2			X^2				
MAG FIELD SURV B (R-7)	X	X		X		X	X	X	X	X	X			X				
COASTAL SAT. (NAS)	X	X		X		X	X	X	X	X	X			X				
OCEAN RESEARCH SAR (E-11)	X	X		X		X	X	X	X	X	X			X				
HVY NUCLEI EXPL (GSF)	X	X		X		X	X	X	X	X	X			X				
OPTIONAL SERVICE MISSIONS																X^2		X^2
1991 MISSIONS																		
SPACE TELESCOPE (A-3)	X	X		X		X		X	X	X	X	X	X	X				
LDEF (01-10)	X	X		X		X	X	X	X	X	X	X		X				
SASP-SCI & APP SP PLAT (U-7 & L-2)	X^2	X^2		X^2		X^2		X^2	X^2	X^2	X^2			X^2				
25kW PWR MOD. (U-8)	X	X		X		X		X	X	X	X			X				
COASTAL SAT. (NAS)	X	X		X		X	X	X	X	X	X			X				
OCEAN RESEARCH SAR (E-11)	X	X		X		X	X	X	X	X	X			X				
HVY NUCLEI EXPL (GSF)	X	X		X		X	X	X	X	X	X			X				
LG SOLAR OBSERV (LEP)	X	X		X		X		X	X	X	X	X	X	X				
OPTIONAL SERVICE MISSIONS																X^2		X^2
1992 MISSIONS																		
SPACE TELESCOPE (A-3)	X	X		X		X		X	X	X	X	X	X	X				
SASP-SCI & APP SP PLAT (U-7 & L-2)	X^2	X^2		X^2		X^2		X^2	X^2	X^2	X^2			X^2				
25kW PWR MOD. (U-8)	X^2	X^2		X^2		X^2		X^2	X^2	X^2	X^2			X^2				
AXAF-ADV X-RAY ASTRO (A-9)	X	X		X		X		X	X	X	X	X	X	X				
CRO-COSMIC RAY OBSER (A-13)	X	X		X		X		X	X	X	X		X	X				
OCEAN RESEARCH SAR (E-11)	X	X		X		X	X	X	X	X	X			X				
HVY NUCLEI EXPL (GSF)	X	X		X		X	X	X	X	X	X			X				
LG SOLAR OBSERV (LEP)	X	X		X		X		X	X	X	X	X	X	X				
SOLAR TERR OBS (S-12)	X	X		X		X		X	X	X	X	X	X	X				
OPTIONAL SERVICE MISSIONS																X^2		X^2

R81-1108-131D-133D
1472-526(T)

NOTE: EXPONENT INDICATES NUMBER OF USES

FOLDOUT FRAME

2 FOLDOUT FRAME

B25 – REVISIT – EQUIPMENT UTILIZATION SUMMARY – DIRECT DELIVERY/SERVICING SATELLITE MISSIONS ('93)
HPA PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT															OPTIONAL EQUIPMENT		
					OCP		MMU/WRU											
1993 MISSIONS	EQUIPMENT STOWAGE PROVISIONS	FLUID TRANSFER SYSTEM	TILT TABLE	RMS	WK PLAT FOR TILT TABLE	OCP/RMS	POM	WITH END EFFECTOR	WITH STABILIZER	WITH PAY-LOAD HDLG	HPA	NONCONT ACS	MTV POM	MTV	VSS	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCEMENT
SPACE TELESCOPE (A-3)	X	X		X		X		X	X	X	X	X	X	X				
SASP-SCI & APP SP PLAT (U-7 & L-2)	X^2	X^2		X^2		X^2		X^2	X^2	X^2	X^2			X^2				
25kW PWR MOD. (U-8)	X	X		X		X		X	X	X	X			X				
AXAF-ADV X-RAY ASTRO (A-9)	X	X		X		X		X	X	X	X	X	X	X				
CRO-COSMIC RAY OBSER (A-13)	X	X		X		X		X	X	X	X		X	X				
OCEAN RESEARCH SAR (E-11)	X	X		X		X	X	X	X	X	X			X				
LG SOLAR OBSERV (LEP)	X	X		X		X		X	X	X	X	X	X	X				
SOLAR TERR OBS (S-12)	X	X		X		X		X	X	X	X	X	X	X				
ADVANCED RELATIVITY (LEP)	X^2	X^2		X^2		X^2		X^2	X^2	X^2	X^2		X^2	X				
AMBIENT DEPLOY IR TELE (A-17)	X	X		X		X		X	X	X	X	X	X	X				
OPTIONAL SERVICE MISSIONS																X^2		X^2

NOTE: EXPONENT INDICATES NUMBER OF USES

R81-1108-134D
1472-527(T)

FOLDOUT FRAME

FOLDOUT FRAME

B26 – REVISIT – EQUIPMENT UTILIZATION SUMMARY – LEO/PROPULSION SATELLITE MISSIONS ('86 TO '89)
HPA PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT															OPTIONAL EQUIPMENT		
	EQUIPMENT STOWAGE PROVISIONS	FLUID TRANSFER SYSTEM	TILT TABLE	RMS	OCP		MMU/WRU				HPA	NONCONT ACS	MTV POM	MTV	VSS	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCEMENT
1986 MISSIONS					WK PLAT FOR TILT TABLE	OCP/RMS	POM	WITH END EFFECTOR	WITH STABILIZER	WITH PAY-LOAD HDLG								
LANDSAT D'' (5 YR)	X	X		X		X	X	X	X	X	X	X		X				
1987 MISSIONS																		
LANDSAT D''' (5 YR)	X	X		X		X	X	X	X	X	X	X		X				
ORBITER CAMERA FR FLYER (MML)	X^3	X^3		X^3		X^3		X^3	X^3	X^3	X^3		X^3	X^3				
NOSS-NAT OCEAN SAT. (E-6)	X	X		X		X		X	X	X	X		X	X				
X-RAY TIME EXPL (A-10, GSF)	X	X		X		X		X	X	X	X	X	X	X				
ICEX-ICE & CLIM EXP (5 YR)	X	X		X		X		X	X	X	X		X	X				
OPTIONAL SERVICE MISSIONS																X^2		X^2
1988 MISSIONS																		
NOAA (E-5)	X	X		X		X		X	X	X	X	X	X	X				
REGION H_2O QUAL MON (LEP)	X	X		X		X		X	X	X	X		X	X				
ORBITER CAMERA FR FLYER (MML)	X	X		X		X		X	X	X	X		X	X				
UARS-UPPER ATMOS RES (E-7)	X	X		X		X		X	X	X	X		X	X				
NOSS-NAT OCEAN SAT. (E-6)	X	X		X		X		X	X	X	X			X	X			
HI ENERGY EXPL (NAS)	X	X		X		X		X	X	X	X		X	X				
ASTROPHYSICS EXPL (GSF)	X	X		X		X		X	X	X	X		X	X				
OP LAND OBSER SYS (LEP (R-5)	X	X		X		X		X	X	X	X		X	X				
OPTIONAL SERVICE MISSIONS																X^2		X^2
1989 MISSIONS																		
ERBS-EARTH RAD BUDGET SAT. (E-4)	X	X		X		X		X	X	X	X	X	X	X				
NOAA (E-5)	X	X		X		X		X	X	X	X			X	X			
ORBITER CAMERA FR FLYER (MML)	X^2	X^2		X^2		X^2		X^2	X^2	X^2	X^2			X^2	X^2			
UARS-UPPER ATMOS RES (E-7)	X^2	X^2		X^2		X^2		X^2	X^2	X^2	X^2		X	X^2	X			
OP LAND OBSER SYS (LEP) (R-5)	X	X		X		X		X	X	X	X			X	X			
ALL WEATHER MICROWAVE (LEP)	X	X		X		X		X	X	X	X			X	X			
EARTH SURVEY (LEP)	X	X		X		X		X	X	X	X	X		X	X			
LAMAR-LG AREA MOD. ARRAY (A-14, GSF)	X	X		X		X		X	X	X	X	X		X	X			
OPTIONAL SERVICE MISSIONS																X^2		X^2

R81-1108-135D-138D
1472-528(T)!

NOTE: EXPONENT INDICATES NUMBER OF USES

FOLDOUT FRAME 1

2 FOLDOUT FRAME

B27 – REVISIT – EQUIPMENT UTILIZATION SUMMARY – LEO/PROPULSION SATELLITE MISSIONS ('90 TO '92)
HPA PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT															OPTIONAL EQUIPMENT		
	EQUIPMENT STOWAGE PROVISIONS	FLUID TRANSFER SYSTEM	TILT TABLE	RMS	OCP		MMU/WRU				HPA	NONCONT ACS	MTV POM	MTV	VSS	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCEMENT
1990 MISSIONS					WK PLAT FOR TILT TABLE	OCP/RMS	POM	WITH END EFFECTOR	WITH STABILIZER	WITH PAY-LOAD HDLG								
UARS-UPPER ATMOS RES (E-7)	x^2	x^2		x^2		x^2		x^2	x^2	x^2	x^2		X	x^2	X			
NOSS-NAT OCEAN SAT. (E-6)	X	X		X		X		X	X	X	X			X	X			
X-RAY TIME EXPL (A-10, GSF)	X	X		X		X		X	X	X	X	X		X	X			
ICEX-ICE & CLIM EXP (5 YR)	X	X		X		X		X	X	X	X			X	X			
OP LAND OBSER SYS (LEP) (R-5)	X	X		X		X		X	X	X	X			X	X			
ADV GEOLOGY SAT. (LEP)	X	X		X		X		X	X	X	X			X	X			
GLOBAL REGIONAL ATHMOS MONITOR (LEP)	X	X		X		X		X	X	X	X			X	X			
LAMAR-LG AREA MOD. ARRAY (A-14, GSF)	X	X		X		X		X	X	X	X	X		X	X			
PRIV EARTH RES (LEP)	X	X		X		X		X	X	X	X	X		X	X			
ATMAS-ADV THERM MAP (R-6)	X	X		X		X		X	X	X	X			X	X			
VLBI-V, LG BASE INT (A-15)	X	X		X		X		X	X	X	X			X	X			
OPTIONAL SERVICE MISSIONS																x^2		x^2
1991 MISSIONS																		
UARS-UPPER ATMOS RES (E-7)	X	X		X		X		X	X	X	X			X	X			
NOSS-NAT OCEAN SAT. (E-6)	X	X		X		X		X	X	X	X			X	X			
ICEX-ICE & CLIM EXP (5 YR)	X	X		X		X		X	X	X	X			X	X			
EARTH SURVEY (LEP)	x^2	x^2		x^2		x^2		x^2	x^2	x^2	x^2	x^2		x^2	x^2			
LAMAR-LG AREA MOD. ARRAY (A-14, GSF)	X	X		X		X		X	X	X	X	X		X	X			
VLBI-V, LG BASE INT (A-15)	X	X		X		X		X	X	X	X			X	X			
ENVIRON MONITOR (LEP)	X	X		X		X		X	X	X	X			X	X			
OP METEOROLOGY (E-10)	X	X		X		X		X	X	X	X			X	X			
ASTRONOMY (MDC)	X	X		X		X		X	X	X	X	X		X	X			
X-RAY OBSERVATORY (GSF)	X	X		X		X		X	X	X	X	X		X	X			
OPTIONAL SERVICE MISSIONS																x^2		x^2
1992 MISSIONS																		
UARS-UPPER ATMOS RES (E-7)	x^2	x^2		x^2		x^2		x^2	x^2	x^2	x^2		X	x^2	X			
OP LAND OBSER SYS (LEP) (R-5)	X	X		X		X		X	X	X	X			X	X			
LAMAR-LG AREA MOD. ARRAY (A-14, GSF)	X	X		X		X		X	X	X	X	X		X	X			
ATMAS-ADV THERM MAP (R-6)	x^2	x^2		x^2		x^2		x^2	x^2	x^2	x^2			x^2	x^2			
VLBI-V, LG BASE INT (A-15)	X	X		X		X		X	X	X	X			X	X			
OPTIONAL SERVICE MISSIONS																x^2		x^2

R81-1108-139D-141D
1472-529(T)

NOTE: EXPONENT INDICATES NUMBER OF USES

FOLDOUT FRAME 1

FOLDOUT FRAME 2

B28 – REVISIT – EQUIPMENT UTILIZATION SUMMARY – LEO/PROPULSION SATELLITE MISSIONS ('93)
HPA PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT															OPTIONAL EQUIPMENT		
					OCP		MMU/WRU											
1993 MISSIONS	EQUIPMENT STOWAGE PROVISIONS	FLUID TRANSFER SYSTEM	TILT TABLE	RMS	WK PLAT FOR TILT TABLE	OCP/RMS	POM	WITH END EFFECTOR	WITH STABILIZER	WITH PAY-LOAD HDLG	HPA	NONCONT ACS	MTV POM	MTV	VSS	ORBITAL STORAGE	ATTITUDE TRANSFER PACKAGE	LIGHT ENHANCEMENT
ERBS-EARTH RAD BUDGET SAT. (E-4)	X	X		X		X		X	X	X	X	X	X	X				
UARS-UPPER ATMOS RES (E-7)	X^2	X^2		X^2		X^2		X^2	X^2	X^2	X^2		X	X^2	X			
OP LAND OBSER SYS (LEP) (R-6)	X	X		X		X		X	X	X	X			X	X			
SCADM-SOLAR CYCLES & DYNAMICS MISS	X	X		X		X		X	X	X	X			X	X			
EARTH SURVEY (LEP)	X^3	X^3		X^3		X^3		X^3	X^3	X^3	X^3	X^3		X^3	X^3			
VLBI-V, LG BASE INT (A-15)	X	X		X		X		X	X	X	X			X	X			
ENVIRON MONITOR (LEP)	X^2	X^2		X^2		X^2		X^2	X^2	X^2	X^2			X^2	X^2			
ASTRONOMY (MDC)	X	X		X		X		X	X	X	X	X		X	X			
OPTIONAL SERVICE MISSIONS																X^2		X^2

R81-1108-142D
1472-530(T)

NOTE: EXPONENT INDICATES NUMBER OF USES

FOLDOUT FRAME

FOLDOUT FRAME

B29 – EARTH RETURN – EQUIPMENT UTILIZATION SUMMARY – DIRECT DELIVERY/SERVICING SATELLITE MISSIONS ('84, '85)
RMS PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT																	
	RETENTION STRUCT	SPEC RETEN-TION STRUCT	EQUIP. STOW. PROV	TILT TABLE	PIDA	OCP		MFR RMS	MMU/WRU			MTV POM	HPA	NONCONTAM ACS	MTV	VSS		
1984 MISSIONS						TILT TABLE WORK PLAT	RMS		W/ END EFFECTOR	WITH STABILIZER	POM					W/ DOCKING RENDEZ	W/ END EFFECTOR	WITH DEBRIS CAPTURE
SPAS-01 STS PALLET SAT.	X							X	X	X^2					X			
1985 MISSIONS																		
SPAS-01 STS PALLET SAT.	X							X	X	X^2					X			
LDEF (01-10)	X							X	X	X^2	X			X	X			

R81-1108-116D-117D
1472-531(T)

NOTE: EXPONENT INDICATES NUMBER OF USES

B30 – EARTH RETURN – EQUIPMENT UTILIZATION SUMMARY – DIRECT DELIVERY/SERVICING SATELLITE MISSIONS ('86 TO '93)
RMS/HPA PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT																	
						OCP			MMU/WRU							VSS		
1986 MISSIONS	RETENTION STRUCT	SPEC RETEN-TION STRUCT	EQUIP. STOW. PROV	TILT TABLE	PIDA	TILT TABLE WORK PLAT	RMS	MFR RMS	W/ END EFFECTOR	WITH STABILIZER	POM	MTV POM	HPA	NONCONTAM ACS	MTV	W/ DOCKING RENDEZ	W/ END EFFECTOR	WITH DEBRIS CAPTURE
SUBSAT FACILITY (S-9)	X							X	X	X^2			X		X			
1987 MISSIONS																		
SPAS-01 STS PALLET SAT.	X							X	X	X^2			X		X			
GRO-GAMMA RAY OBSERV (A-7)	X				X			X	X	X^2		X	X		X			
SUBSAT FACILITY (S-9)	X							X	X	X^2			X		X			
1988 MISSIONS																		
LDEF (01-10)	X							X	X	X^2	X		X	X	X			
SUBSAT FACILITY (S-9)	X							X	X	X^2			X		X			
1989 MISSIONS																		
SPAS-01 STS PALLET SAT.	X							X	X	X^2			X		X			
SPACE TELESCOPE (A-3)	X			X		X		X	X	X		X		X	X			
SUBSAT FACILITY (S-9)	X							X	X	X^2			X		X			
1990 MISSIONS																		
SUBSAT FACILITY (S-9)	X							X	X	X^2			X		X			
AXAF-ADV X-RAY ASTRO (A-9)	X							X	X	X^2		X	X	X	X			
CRO-COSMIC RAY OBSER (A-13)	X				X			X	X	X		X	X		X			
GRAVITY PROBE B (A-8)	X							X	X	X^2		X	X		X			
1991 MISSIONS																		
SPAS-01 STS PALLET SAT.	X							X	X	X^2			X		X			
25kW PWR MOD. (U-8)	X				X			X	X	X			X		X			
MAG FIELD SURV B (R-7)	X							X	X	X^2	X		X		X			
SUBSAT FACILITY (S-9)	X							X	X	X^2			X		X			
1992 MISSIONS																		
LDEF (01-10)	X							X	X	X^2	X		X	X	X			
COASTAL SAT. (NAS)	X							X	X	X^2	X		X	X	X			
1993 MISSIONS																		
SPAS 01 STS PALLET SAT.	X							X	X	X^2			X		X			
25kW PWR MOD. (U-8)	X				X			X	X	X			X		X			
HVY NUCLEI EXPL (GSF)	X							X	X	X^2	X		X		X			

R81-1108-118D-125D
1472-532(T)

NOTE: EXPONENT INDICATES NUMBER OF USES

FOLDOUT FRAME

FOLDOUT FRAME

B31 – EARTH RETURN – EQUIPMENT UTILIZATION SUMMARY – LEO/PROPULSION SATELLITE MISSIONS ('84 TO '87)
RMS/TILT TABLE PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT																	
						OCP			MMU/WRU							VSS		
1984 MISSIONS	RETENTION STRUCT	SPEC RETEN-TION STRUCT	EQUIP. STOW. PROV	TILT TABLE	PIDA	TILT TABLE WORK PLAT	RMS	MFR RMS	W/ END EFFECTOR	WITH STABILIZER	POM	MTV POM	HPA	NONCONTAM ACS	MTV	W/ DOCKING RENDEZ	W/ END EFFECTOR	WITH DEBRIS CAPTURE
CHEM REL MODULE (S-5)	X							X	X	X^2	X				X			
SOLAR MAX-SMM	X			X		X		X	X	X	X				X			
1986 MISSIONS	RMS/HPA & RMS/TILT TABLE PRIME USAGE																	
LANDSAT D (R-2)	X			X		X		X	X	X	X			X	X			
CHEM REL MODULE (S-5)	X							X	X	X^2	X		X		X			
ERBS-EARTH RAD BUDGET SAT. (E-5)	X			X		X		X	X	X	X			X	X			
NOAA (E-5)	X			X		X		X	X	X		X		X	X			
1987 MISSIONS																		
COBE-COSMIC BKGND EXPL (GSF)	X			X		X		X	X	X					X			
EUVE-EXTREME UV EXPLORER (A-5)	X							X	X	X^2		X	X	X	X			
ORBITER CAMERA FR FLYER (MML)	X							X	X	X^2		X	X		X			
MAGSAT B (R-1)	X							X	X	X^2		X	X		X			

R81-1108-107D-109D
1472-533(T)

NOTE: EXPONENT INDICATES NUMBER OF USES

FOLDOUT FRAME 1

FOLDOUT FRAME 2

B32 – EARTH RETURN – EQUIPMENT UTILIZATION SUMMARY – LEO/PROPULSION SATELLITE MISSIONS ('88 TO '91)
RMS/HPA PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT																	
	RETENTION STRUCT	SPEC RETEN-TION STRUCT	EQUIP. STOW. PROV	TILT TABLE	PIDA	OCP		MFR	MMU/WRU			MTV POM	HPA	NONCONTAM ACS	MTV	VSS		
1988 MISSIONS						TILT TABLE WORK PLAT	RMS		W/ END EFFECTOR	WITH STABILIZER	POM					W/ DOCKING RENDEZ	W/ END EFFECTOR	WITH DEBRIS CAPTURE
LANDSAT D'' (5 YR)	X			X		X		X	X	X	X			X	X			
NOSS-NAT OCEAN SAT. (E-6)	X							X	X	X^2		X	X		X			
X-RAY TIME EXPL (A-10, GSF)	X							X	X	X^2		X	X	X	X			
ICEX-ICE / CLIM EXP (5 YR)	X							X	X	X^2		X	X		X			
1989 MISSIONS																		
LANDSAT D''' (5 YR)	X			X		X		X	X	X	X			X	X			
ORBITER CAMERA FR FLYER (MML)	X							X	X	X^2		X	X		X			
NOSS-NAT OCEAN SAT. (E-6)	X							X	X	X^2			X		X	X		
OP LAND OBSER SYS (LEP) (R-5)	X							X	X	X^2		X	X		X			
1990 MISSIONS																		
NOAA (E-5)	X			X		X		X	X	X		X		X	X			
REGION H20 QUAL MON (LEP)	X							X	X	X^2		X	X		X			
HI ENERGY EXPL (NAS)	X							X	X	X^2		X	X		X			
ASTROPHYSICS EXPL (GSF)	X							X	X	X^2		X	X		X			
OP LAND OBSER SYS (LEP) (R-5)	X							X	X	X^2			X		X	X		
TOPEX-TOPOG EXP OCEAN CIRCULAT	X							X	X	X^2			X		X	X		
SCADM-SOLAR CYCLES & DYNAMICS	X							X	X	X^2			X		X	X		
1991 MISSIONS																		
ERBS-EARTH RAD BUDGET SAT. (E-4)	X							X	X	X^2		X	X	X	X	X		
NOAA (E-5)	X							X	X	X^2			X	X	X	X		
X-RAY TIME EXPL (A-10, GSF)	X							X	X	X^2	X		X	X	X	X		
OP LAND OBSER SYS (LEP) (R-5)	X							X	X	X^2			X		X	X		
ALL WEATHER MICROWAVE (LEP)	X							X	X	X^2			X		X	X		
GAMMA-RAY TRANSIENT EXPL (GSF)	X							X	X	X^2			X	X	X	X		
UV PHOTOMET/POLARIMET EXPL (GSF)	X							X	X	X^2			X	X	X	X		

R81-1108-110D-113D
1472-534(T)

NOTE: EXPONENT INDICATES NUMBER OF USES

FOLDOUT FRAME

FOLDOUT FRAME

B33 – EARTH RETURN – EQUIPMENT UTILIZATION SUMMARY – LEO/PROPULSION SATELLITE MISSIONS ('92, '93)
RMS/HPA PRIME USAGE

SATELLITE	NOMINAL EQUIPMENT																	
	RETENTION STRUCT	SPEC RETEN-TION STRUCT	EQUIP. STOW. PROV	TILT TABLE	PIDA	OCP		MFR RMS	MMU/WRU			MTV POM	HPA	NONCONTAM ACS	MTV	VSS		
1992 MISSIONS						TILT TABLE WORK PLAT	RMS		W/ END EFFECTOR	WITH STABILIZER	POM					W/ DOCKING RENDEZ	W/ END EFFECTOR	WITH DEBRIS CAPTURE
NOSS-NAT OCEAN SAT. (E-6)	X							X	X	X^2			X		X	X		
ICEX-ICE & CLIM EXP (5 YR)	X							X	X	X^2			X		X	X		
ADV GEOLOGY SAT. (LEP)	X							X	X	X^2			X		X	X		
GLOBAL REGIONAL ATHMOS MONITOR	X							X	X	X^2			X		X	X		
PRIV EARTH RES (LEP)	X							X	X	X^2			X	X	X	X		
SOFT X-RAY SURVEY (GSF)	X							X	X	X^2			X	X	X	X		
X-RAY SPECTROSCOPY (GSF)	X							X	X	X^2			X		X	X		
1993 MISSIONS																		
NOSS-NAT OCEAN SAT. (E-6)	X							X	X	X^2			X		X	X		
LAMAR-LG AREA MOD. ARRAY (A-14)	X							X	X	X^2			X		X	X		
OP METEROLOGY (E-10)	X							X	X	X^2			X		X	X		
MOLECALAR LINE SURVEY	X							X	X	X^2			X		X	X		

R81-1108-114-115D
1472-535(T)

NOTE: EXPONENT INDICATES NUMBER OF USES

FOLDOUT FRAME 1

FOLDOUT FRAME 2